THE SCREW-CUTTING LATHE

HOW TO SELECT, SET UP, ADJUST AND OPERATE

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NEW YORK
McGRAW PUBLISHING COMPANY
1907

GREETING

To the young man—particularly the young blacksmith—who is endeavoring to increase his usefulness this volume is directed, that he may perhaps by its perusal be enabled to make use of my years of experience and thereby be able to do more and better work and increase his usefulness and earning capacity.

JAMES F. HOBART.

Willoughby, Ohio,
June 15, 1907

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CHAPTER I.

SELECTION OF A LATHE.

Hardly a day passes but the progressive smith sees opportunity for increased profit if his shop contained some appliance for doing a little machine work. Particularly is this the case when automobile work is to be done, but in the ordinary run of custom work there are numberless opportunities for work which has to be "sent to the machine shop" because there is no machine in the smithy which can be made to turn up a journal bearing or face up a collar or a flange. There are also numerous opportunities for making work when a good lathe is at hand, and the smith who once has a good tool of this kind in his shop will never again be without one.

The smith who has an idea of putting in a screw-cutting lathe should lose no more time thinking over the matter. Secure the lathe at once, and then begin to be sorry—that it was not secured long before. The worst question the smith is called upon to decide is "What size of lathe is it best to purchase?" This is a very hard question to decide, for no matter what size of lathe is purchased there will come a time when it is entirely too small. Next, the time comes when the lathe is entirely too large for the work that should be done upon it.

THE BEST SIZE OF LATHE TO BUY.

Probably the size of lathe which will give the most universal satisfaction to the smiths has a bed seven or eight feet long and will take a length of four feet between centers. That is a piece of iron four feet long can be put between the two centers. The lathe should swing at least sixteen inches. This means that a pulley on a short shaft can be put in the lathe as long as the pulley diameter does not exceed sixteen inches or the length of the

shaft exceed forty-eight inches. But this does not mean that the 16-inch pulley will let the slide-rest pass under it. No object much larger than eight inches in diameter can pass the slide-rest, consequently the lathe man describes that particular size as "swings 48 inches between centers, 16 inches over shears and 8 inches over saddle." These dimensions represent the limit of work that can be put into a lathe of that size, and the smith should keep his eye open for some time in regard to the possible lengths and diameters of work he expects to handle in the new lathe. However, for the general run of smithy work a lathe of the above-named dimensions should answer very well.

There are numberless makeshifts for doing large work in a small lathe, and the writer well remembers the wooden blocks to put under the head and tail-stock when larger work than the lathe would swing had to be done. And there was also the wooden extension which was bolted to the end of the lathe-bed to carry the tail-stock when something three feet or so longer than the lathe bed had to be put between centers. There is almost no limit to the capacity of a small lathe for large work, therefore select a lathe which is very strong and which will stand the severe demands sure to be made upon it. Pay no attention to a fancy lathe. Put every cent of the money you have to spend into strong, well-fitted spindles, good head and tail-stocks and a heavy well-fitting slide-rest on substantial Vs of a well-proportioned lathe bed. Then there will be little danger of making a wrong selection of a lathe.

SELECTING A SECOND-HAND LATHE.

The writer would always advise the smith to buy a new lathe if possible, but there are sometimes circumstances which forbid the new tool while a second-hand one may be in sight. There are many excellent second-hand lathes, but it requires a man accustomed to lathes to pick out a good one. There are a few simple things to be looked at which will prevent the smith from selecting a lathe which has been too badly worn. First, look over the entire machine for signs of wear and hard usage. If the bed has been hammered, and Vs all dented and jammed up, the tool-post hammered out of shape, the gears broken or worn thin, then the smith may well leave that lathe to the junk man and pass to the next tool.

Next, if there are not signs of excessive wear and abuse as above noted, look to the condition of the spindle. See if it has gotten out of center, sidewise or vertically, even to the slightest degree. This point may usually be determined pretty closely by looking at the front end of the spindle where it leaves the bearings. If there be the slightest appearance of eccentricity between the spindle and the ends of the bearings, then it is safe to assume that the bearings of the spindle, or both have become worn too much to permit of good work until the lathe has been overhauled in the machine shop.

TESTING HEAD AND TAIL-SPINDLES.

Put a bit of plank under the end of the spindle, run the slide-rest up to the head-stock and take a pry over the slide-rest with the plank. If there be any lost motion between the spindle and its bearing, the fact can be readily determined by the movement of the spindle when force is applied to the bit of plank.

The same test may be applied to the tail-spindle to find if it be considerably worn. At the same time the spindles, both head and tail, should be so adjusted that they both move easily and freely in their respective housings. The cones of head-spindle and clamp of tail-spindle can be so closely adjusted that the "pry-test" above described will reveal nothing, even though the wear may have been considerable. The condition of the lathe for this test must be normal and exactly as for actual work.

The condition of the slide-rest and its movement upon the Vs of the lathe bed should next receive attention. There is danger that the lathe bed may have been worn near the head-stock, as, owing to the fact that a large proportion of the entire work done on a lathe is very short, the Vs become worn down just at the front end of the head-stock and the lathe becomes of very little use for long work.

TESTS FOR WEAR IN THE BED.

A good test for wear of the Vs is a very accurate short straight-edge laid upon the Vs between the head-stock and the tail-stock in its farthest position. Hold the straight-edge in place by means of two weights, one at either end. Place a piece of paper between straight-edge and V, and move paper along to see if it be pinched as much in one place as in another. Some

old lathes show one-sixteenth inch vertical wear in the top of the front V, which wears much faster than the back V. But vertical wear alone does not always prevent a lathe from doing a fair job of straight turning. It is the lateral wear of the Vs, and this must be tested also by putting a tool in the post on the slide-rest and then clamping the straight-edge flat upon its side parallel to the lathe bed in such a manner that the tool will just pinch a piece of paper laid against the straight-edge between it and the tool.

With the straight-edge clamped as described, move the slide-rest from one end of its travel to the other, testing continually with the piece of paper between the straight-edge and the fixed tool. If the paper is as tight at one place as another the Vs are evidently in first-class condition, but if, as is pretty apt to be the case, the paper is loose most of the way and tight only in one or two spots, then the smith may well squint sidewise at the lathe in question and say: "To the shop for yours, another lathe for mine." If any second-hand lathe passes the above tests, then it is worth taking slightly apart so as to see the condition of the bearings in the cones and on the spindles. The apron should also be overhauled a little to see that there is nothing broken there. See that the wear in the apron is not too great. This can be done by noting how far it is necessary to turn the handle one way or the other in order to start the slide-rest amoving in one direction or the other. If not over one-sixth of a turn is necessary the lathe is in not very bad condition in that direc-

TESTS FOR THE LEAD-SCREWS.

Close the nut upon the lead-screw and repeat the same test to see how badly the nut is worn. Probably the handle will move farther in either direction in this test than it did before the slide-rest commenced to move in the last test. The difference in movement of the handle is due to the wear of the lead-screw nut. The actual movement of the slide-rest is the amount of wear in the nut. If this movement is one-sixteenth inch or over a new nut will be required. Make this test in different parts of the lead-screw. If the lost motion of the rest is the same at all points a new nut will cure the trouble, but if the motion varies the screw itself is badly worn and the smith had best pass along to another and less ancient lathe.

The smith may not have determined fully just what kind of a lathe he ought to purchase and it is by no means clear to him what kind is the most desirable for the work he expects to do. From the points noted above the smith will be pretty apt to select a new lathe or one which has been thrown on the market when nearly new, by some cause other than the lathe being in any manner defective. But such bargains are usually scarce and not always to be depended upon, while the new lathe is always in evidence and a sure bargain.

WHAT KIND OF LATHE.

But as to the kind of lathe to buy: By all means purchase a back-geared, screw-cutting lathe with both rack and screw feeds, reverse motion in the head-stock—or somewhere else, as in some makes of lathe, and see that the lathe has a hollow spindle in the head-stock and a split clamp in the tail-stock. See also that the tail-stock has ample provision for being offset sidewise for the purpose of turning taper shapes. The step-cone in the head-stock should have at least four steps for the belt and the step-cone should be fastened to the main gear by means of a bolt, which merely slips in and out of gear sidewise when the change in gear is to be made.

Do not select an old-fashioned lathe in which the bolt takes out entirely when the back gear is to be put into mesh. The nut for the screw alongside the lathe (the lead-screw) should also be examined to see that the nut is split and is operated by a cam. Some old-time lathes have a solid nut which has to be attached to the slide-rest by means of a bolt or two every time a screw thread is to be cut. Don't look but once at a lathe of this kind.

See that there is plenty of metal in the bed of the lathe. A weak, thin bed which will spring out of shape under the strain of a heavy cut is not at all desirable. Most lathes have heavy beds, but the smith knows not what he will be "up against" when he gets into the market, therefore, "watch out."

THE OVERHEAD COUNTERSHAFT.

The overhead countershaft also needs looking after. There should be upon that shaft, together with the step pulley to match the pulley on lathe, a pair of friction clutches for stopping or starting the go-ahead and the backing-up motions. The lathe

countershaft must be connected with the pulleys on the main shaft by means of two belts, one open, the other crossed, and it is not at all desirable that these belts be connected with the lathe countershaft by means of either tight and loose pulleys, jaw clutches, or dogs on the countershaft which can be made to engage with either one of the pulleys mentioned above. Insist upon a pair of friction pulleys, and that, too, upon cone frictions the engaging surfaces of which are plain cast iron and entirely free from all surfaces of paper, wood, leather or other substances. Plain cast-iron cones are the things for lathe countershaft frictions—and they are most excellent for other friction pulleys, too.

HOW TO USE THE LATHE.

This will be the question fired in by very many readers who have just bought lathes and wish to learn just how to use them to the best advantage. To see a machinist stand and watch a nice sharp tool cut a nice clean shaving and leave the work smooth and of just the right diameter required is a quite different thing from what happened when the first piece of work was put into your lathe! To be sure, you made the centers with a prick-punch, and were not very particular as to what kind of tool was put in the tool-post, or just how that tool was set. No wonder that the bit of iron you wished to make into a nice pin persistently refused to become either round, straight or of the desired diameter. Never mind, these things will all be taken care of in proper order, but there are an awful lot of such things to be looked after, and as yet we have not even gotten the lathe set up and leveled properly. And then there is the lathe bed to get "out of wind." The size of pulleys on main shaft must be determined to make the lathe run at the right speed, then the countershaft must be fastened up, the belts laced properly and then the lathe must be made ready for use.

The centers must be trued up and put in line, perhaps the tail-center will need hardening and grinding, and surely the head and tail spindles must be properly adjusted, the slide-rest oiled and adjusted and other things looked to. Do lathe work now? Might as well try to weld before a fire has been built in the forge.

CHAPTER II.

SETTING THE BED.

A lathe usually comes into the shop mounted on skids, which are merely two pieces of plank or joists a little longer than the lathe bed and fastened to the feet of the lathe by means of four lag screws. Such cross bracing as may be found necessary connects the two skids. Do not remove the skids until the lathe has been moved on small rollers or short pieces of pipe to almost the exact spot it is to occupy. The countershaft will probably be found fastened to the skids, together with one or more boxes containing the loose pieces of the lathe, together with the easily removable small parts, such as the various handles, tool post, wrenches, etc.

Having determined the exact spot where the lathe is to stand, stretch a string or chalk line parallel to the main shaft and high enough above the floor to let the lathe pass under the line, then bring the lathe into place under the line, take off the skids and let the legs down carefully upon the floor. It is best to use a small timber as a lever for this purpose, taking a pry under the bed of the lathe, and taking great care not to damage any of the screws or the rack, or to drop the lathe legs upon the floor. Do not let it drop even to the extent of an inch. Having gotten the skids off, and the lathe upon the floor, use a spirit level to make the bed of the lathe exactly level, both lengthwise and crosswise the bed. It is very seldom that the floor is so perfectly level that the four legs of the lathe will have an equal bearing, therefore it is necessary to "shim up" under the feet of the lathe as may be found necessary to make each foot bear evenly upon the floor. While the shimming and leveling is being done the lathe must be exactly in the place where it is to stand.

It is good practice to suspend a plumb-bob or a small weight on a string from the long line above mentioned at either end of the lathe and to bring the ends of the spindles exactly in line with the plumb lines. Lag screws had better be put through two of the lathe feet and the screws left sticking up an inch to allow of the

necessary wedging under the feet. In this manner the lathe will be kept in line until the feet have been temporarily wedged up and permanent pieces fitted under each foot in place of the wedges, after which the lathe may be screwed down permanently. It is well to take a little time and make a good job of the above work. Although any good lathe should be so designed that it will do good work with the bed supported at opposite diagonal corners, there are but very few lathes which will not give better results when perfectly bedded upon a good solid foundation and perfectly leveled and aligned with the main shaft of the shop or with the engine.

THE COUNTERSHAFT.

This is usually a piece of shafting 1½ inches in diameter by 3 feet to 3 feet 6 inches long, with a pair of drop hangers for attaching shaft to ceiling overhead. There is also a pair of crown face pulleys on the shaft which normally run loose, but either of which may be rigidly connected with the shaft at will by the movement of a lever in one direction or the other. One of these pulleys is known as the "go-ahead" pulley, the other as the "reverse" or "backing" pulley.

Attached to each lathe should be printed directions stating the speed at which the countershaft should run, and in erecting the shaft, care should be taken to obtain pulleys for the main shaft which will give the required speed. For instance: If the counter is to run at 150 revolutions per minute and the main shaft runs at 200 revolutions (in all future chapters the speed of a shaft or machine will be stated thus: 200 RPM., meaning 200 revolutions per minute), with pulleys 16 inches in diameter on the countershaft, what diameter of pulleys on main shaft will give the counter a speed of 150 RPM.?

It is best to state all these examples in a simple fraction-proportion form, as follows:

$$\frac{\text{Speed of driving pulley} \times \text{dia. of drive pulley.}}{\text{Diameter of driven pulley} \times \text{speed of driven pulley.}}$$

Substituting the numbers, it becomes: $200 \div 16 \times 150 = 12$, the diameter of the pulley required on main shaft to drive the countershaft at 150 RPM., the answer may be found by multiplying together the numbers below the line and dividing the result by the number above the line, or cancellation may be used.

It makes no difference how many countershafts or pulleys it is desired to calculate speed through. Just put them all in line as above, with the speed of first shaft and the diameter of all driving pulleys on top of the line and put diameters of all driven pulleys below the line, then cancel or multiply and divide clear through and the resulting number will be the diameter of pulley or the speed of shaft required, as the case may be.

FITTING THE BELTS.

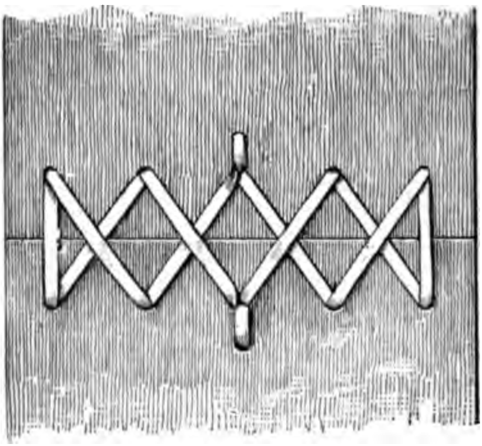
Having put the countershaft in place, leveled it carefully and carefully aligned it to the main shaft, the belts may be put on as follows: Run a tape measure or a string which does not stretch around a pair of pulleys, taking care to pass the tape on either of the edges or in the middle of both pulleys—it matters not which as long as the tape does not run criss-cross from side to side of the pulleys—then carefully note the length of the belt required. If the tape calls for 16 feet 6 inches of belt, then actually cut the leather 2 1-16 inches short of the tape measurement. Allow ⅛ inch per foot of belt is the usual rule, and it comes out pretty close.

Three belts will be required for the lathe; one from the stepped cone to the countershaft and two belts from counter to main shaft. One of this pair of belts must be crossed, the other must be open. In some lathe arrangements the "backing" pulley is smaller than the "go-ahead" pulley in order that in screw cutting the carriage may return the tool for a new cut faster than is permissible in the cutting movement itself. But in the more modern lathes the carriage is usually run back by hand, "catching" the thread at the proper instant, as will be described later. This allows both countershaft pulleys to be made of the same size, hence the "backing" belt may be placed on either, as desired. It will be found that the crossed belt requires a little more leather than the open belt, owing to the diagonal position of the folds.

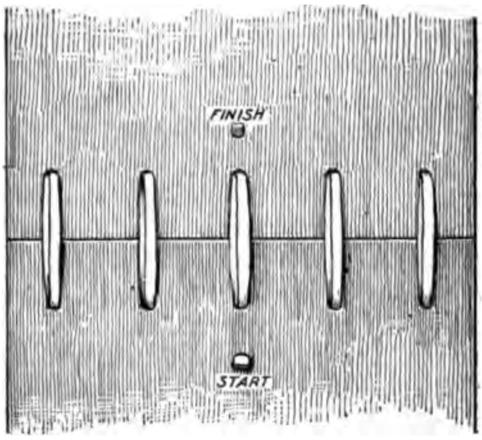
PUNCHING HOLES AND LACING.

Once the proper length of belt has been determined, cut the ends of the belt off square, using a carpenter's try-square for marking the leather—do not try to guess at the squareness of the cut. It pays to mark the belt as directed and then cut the leather cleanly with a very thin, sharp knife. A "belt box" should be established at once, and in that box should be kept all the tools nec-

essary for mending or splicing belts. Have a cover to the bo for rats dearly love to chew up good belt lacing. Buy a "sh knife" for ten cents and put it in the belt box, and under no ci



OUTSIDE

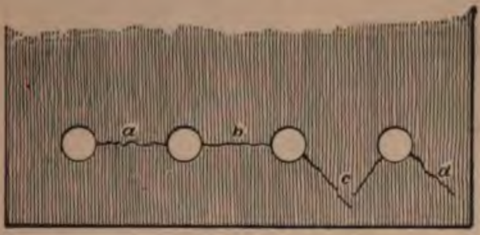


PULLEY SIDE
Fig. 1—Good Method of Lacing Belt.

cumstances whatever are that knife or the other tools in the box t be used for other work than lacing belts.

There are innumerable ways of lacing belts, and perhaps man ways as good as those shown here, but belts laced by either metho will give perfect satisfaction in any shop. The first metho shown by Fig. 1, is a good form of ordinary lacing where the end

of the belt are joined with a narrow strip of rawhide. For any belt likely to be used in a smith shop a lacing should never be cut more than 3/8 inch wide. It is better 5-16 inch wide. The lacing should always be narrow and the holes small. A number of large holes punched through a belt weakens it very much and such holes should be avoided. Take a 4-inch belt and punch 3/8-inch holes across the end. The man who does this without a thorough understanding of the matter will usually punch four holes in a row, somewhat as shown by Fig. 2 at A, where the holes are



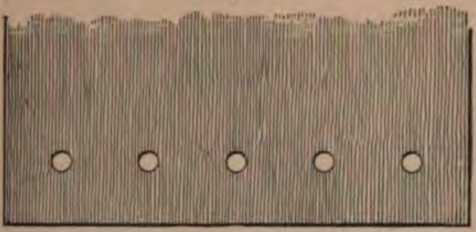


Fig. 2—Improper and Proper Punch Holes.

punched as described above. At B is shown a much better layout and the value of the two methods is as follows: In sketch A, 4 × 3/8 inch of belt has been cut out of 4 inches, leaving 2½ inches, or 62½ per cent. of the belt at the splice to do the work of the rest of the 4-inch belt. In case of the belt holes shown by sketch B, the five 3-16 inch holes, cut 15-16 inch from the belt, leaving 3 1-16 inch or 76½ per cent. of leather.

There is also another point to be considered. If we were calculating the strength of strap iron or boiler plate the above-noted method would be sufficient, but belts do not break square across from hole to hole as at a and b, Fig. 2, sketch A. Instead of this the leather will tear at an agle of about forty-five degrees, as shown at c and d. Taking this view of the case, there are ten

pieces of belt in B to be torn, against eight in A, therefore t strength of the two belts is as 10 to 8, or as 5 to 4. By a glar at sketch A it will be seen that the tearing at c comes to a po before it reaches the edge of the belt. This tells that it is u

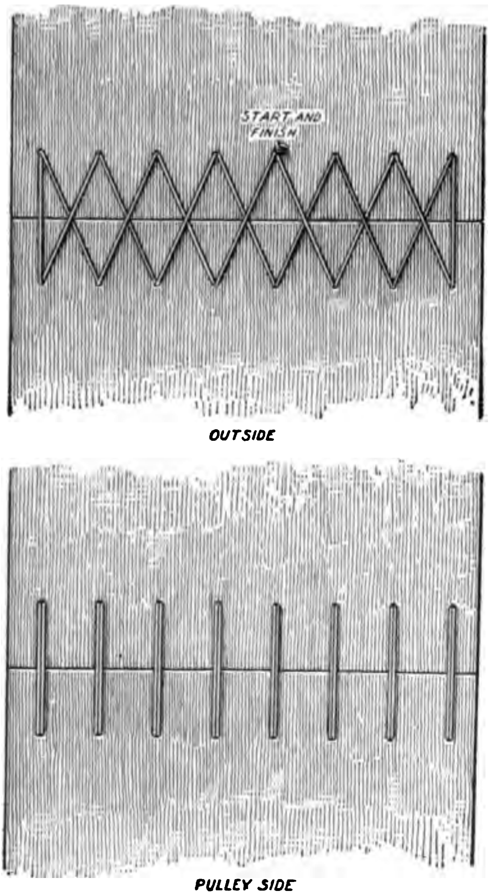


Fig. 3—Excellent Wire Lacing.

necessary to have so great a distance between the row of holes an the end of the belt. It also tells that the more holes and th smaller in diameter the stronger will be the belt splice or joint.

In Fig. 1 the lacing is shown as beginning and ending at th middle of the belt. This should always be done. An awl ho should be made, the lacing forced through, and a knife cut mad

in the edge of the lacing about one-third across, close to the surface of the belt, then the lacing should be cut off ⅜ or ½ inch longer, and the ends left hanging on the side of belt next to the pulley. Such a lace fastening will never slip if properly made. The front and pulley sides of the belt are shown, and the lacing should be disposed as shown, with no crossing of the strands on the pulley side of the belt, otherwise the lacing will cut quickly.

Fig. 3 shows a most excellent form of belt splice for lathes and general machine-shop work. The wire is made specially for the purpose and is very strong and flexible. It can be purchased in small coils in little boxes, all ready for use. When the holes

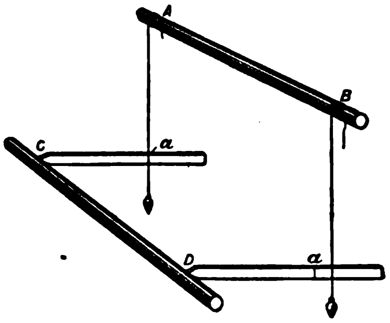


Fig. 4—Aligning Shafting.

are punched with an awl no belt material will be removed, therefore there is 100 per cent. of belt strength at the joint, and sixteen strips of tearing to be done before the splice can be pulled apart, hence the great strength of a splice of this kind. It will be seen that there is no crossing of wires on the inside or pulley side of the belt, otherwise the wires would quickly cut each other in two. The ends of the wire are twisted together in the middle of the belt. One thing more must be done or the splice will be worthless: the wires must be hammered into the belt so as to be even with or below the surface thereof, otherwise the splice will not last long. Put the splice on an iron pulley and hammer it well but lightly, taking care not to let the wires cut the belt, only to sink into the leather.

ALIGNING THE COUNTERSHAFT.

Some people make a great deal of hard work about a very simple operation, notably in aligning shafting. The whole thing is shown in a nutshell by Fig. 4. Just hang two plumb-bobs on

the same side of main shaft at G and B; then place a square pointed stick against the counter at C, and mark at a, the bob-line. Carry the same stick to D, and if the bob-line touches the mark a the shafts are in line. If not, as shown in the drawing, move the shaft until they coincide. Test both at C and D at least twice each.

CHAPTER III.

MAKING READY FOR USE.

The belts having been put in place, see that they all run fair upon the several pulleys. Usually pulleys are made about half an inch wider than the belts that should run upon them and if any belt seeks to run over the edge of a pulley, then there is something wrong with the aligning and levelling of the lathe or shaft. Look for and cure the trouble before going farther. Never, under any circumstances, be guilty of the unmechanical trick of nailing up a piece of board to guide the belt and to keep it on the pulley. Sometimes there may be a crooked place in the belt which should be cut out, but otherwise, unless the pulleys themselves are badly turned and left conical on their faces, the trouble is surely in not setting the pulleys square and level with each other.

Put some oil in the spindle bearings—we will adjust them later—and start the lathe to running. See that the belts all run fair, "track," they call it, with no tendency to seek either edge of any pulley, then see that the same thing happens with the belt between the step pulleys on lathe and counter. Sometimes a slight movement of the lathe endwise is necessary to make the belt run fair, but run fair it must, without chafing against the higher steps of the cone or running over the edge of any step.

"SETTING-UP" THE HEADSTOCK.

At this stage of the game it is well for the "smith-machinist" to become thoroughly familiar with the construction of the lathe, with the various mechanical movements contained in the headstock and slide rest, and to this end it is necessary to take down the lathe to a considerable extent. But right here, a word of warning: Don't take down the whole lathe at the same time. Investigate a bit at a time. If the entire lathe be taken down there will be a hopeless mix-up of parts and something will surely be broken or damaged. Instead of wholesale dismember-

ment, take down only a small portion at a time as in the present instance, only the main bearing will be investigated.

Take off the belt by giving it a flirt with the hand while the lathe is running. The particular knack of throwing a lathe belt off and on the cone pulleys must be studied and practiced until it can be done the first time trying. There is a "knack" about it, that's all. By a little practice, a belt can be snapped from each smaller step on the upper pulley to the next larger step until the largest one is reached. To do it the belt is run on to the smallest lower step with one hand while with the other hand the "going up" fold of the belt is so guided that it cannot run off upon the next smaller step of the upper pulley. Then with a quick snap the belt is jerked sidewise with a twist which flips it neatly upon the next larger step of upper pulley. This trick can only be learned by practice—and lots of it.

Take down the main bearing of the spindle—the bearing next to the body of the lathe—and note well the manner in which the bearing is arranged so that wear can be taken up. Note well also the adjustment provided for taking up wear and for keeping the bearing tight and well fitting. Usually the front bearing is a cone while the other bearing is straight. Sometimes both bearings are cone or taper, but not in the best lathes.

ADJUSTING THE SPINDLE BEARINGS.

See that the bearings are free from grit or other dirt, and study well the method of adjusting the cone. After replacing the caps, adjust the take-up screw in such a manner that the bearing will run easily but without the least lost motion. As the spindle should be hollow, the screw at end of headstock should be hollow also, and quite a large check-nut is necessary to hold the screw after it has been adjusted. Usually the setting up of the check-nut will be enough to loosen the cone enough to let it shake a trifle, therefore this point must be looked to by setting the screw a trifle too tight and then the check-nut will slack it just enough to bring the spindle free but tight.

PUTTING THE CENTERS IN LINE.

A lathe as it comes from the shop is supposed to have the centers in exact alignment, but this supposition cannot be trusted. The fact must be shown, and every time the lathe is

used on an extra nice piece of work it is necessary to apply the test which is as follows: Select a piece of shafting or round iron or steel between one and three inches in diameter and as long as will go easily between the lathe centers.

Put a sharp tool in the tool post and adjust until the cutting point is exactly as high as the points of the lathe centers. Take a cut over an inch or two of both ends of the test bar, as we will call it. Commencing the cut next to the tail center, and reversing the test piece in the lathe to cut the other end. Both roughing cuts having been made, sharpen the tool and take another light cut (as smooth as possible) on the end of test piece next to tail spindle. Cut only about one inch in length, then, without moving the tool in the least, remove the test piece from the lathe, after which carefully run the carriage back so the tool will be close to the tail-center, but be sure not to move the tool itself, either to or from the work by means of the cross-feed screw, which must not be touched at all during the operation.

Reverse the dog on the test piece and replace in the lathe, then make a finishing cut on the other end of the test piece without altering the position of the tool in the least except as the feed moves it along the lathe bed. Having completed the finishing cut, remove the dog from the work, adjust nicely between centers so there will be no play whatever, then without altering in the least the vertical position of the lathe tool, run that useful appliance forward by means of the cross-feed screw until the tool barely touches the piece of metal between the lathe centers.

While the above-noted action is taking place, move the slide rest lengthwise of the lathe an inch or so, and keep the carriage reciprocating back and forth while the tool is being forced very slowly toward the piece between centers. When as above, the tool barely touches the work, leave the tool in that position and move the carriage on the lathe so that the tool marks a very fine straight line along the work. Without moving the cross feed, or touching the tool, remove the work from the lathe and run the carriage ahead until the tool is close to the head-center. While the tool is in that position replace the work between centers, adjusting them exactly as before, and proceed to mark a line on the turned portion of the shaft next to the head-center.

It is ten to one that either the tool will not touch the shaft at all, or that it will want to make a very deep mark. In either

case, the lathe centers are out of line with the lathe bed and if the shaft be turned from one end to the other, it will come from the lathe cone-shaped instead of a true cylinder.

MOVING THE TAIL-CENTER.

The tail-center is so arranged that it may be moved laterally by unclamping from the lathe bed and then backing up one screw and tightening another. This adjustment should be made and the line-marking repeated as above described, taking care to always set the tail spindle mark last. That is, the mark should be first made on the end of shaft at head end of lathe and the other test made at the tail-center whereupon the necessary adjustment may be made at once, which would not be the case if the mark were made first on tail-center end of shaft between lathe centers. A slight taper may readily be turned in any lathe by setting over the tail-stock so that one side of the required cone will come parallel with the lathe bed. It is partly for the reason that the tail-stock is liable to be set over at any time that the above described test is necessary before any turning requiring precision is to be commenced.

After the centers have been centrally adjusted, a mark is usually made on the tail-stock by the maker of the lathe. Although this mark may be used for setting the centers for ordinary work, it should not be depended upon for close work, and the centers should be tested as above for every important setting of the lathe. At least three tests at each end of the lathe should be made to get an exact setting of the centers. This is necessary for the reason that when one end of the short shaft is moved by screwing over the tail-center, the line-drawing tool is thrown out of truth with the line first drawn, hence the many tests necessary to bring the two ends of the shaft between centers perfectly parallel with the marking tool.

TRUING UP, HARDENING AND GRINDING.

Both the centers, the tail-center especially, are apt to become worn by use and must be put in shape, as often as they depart from a true cone shape of 60 degrees. A good way to make a center gauge is to make a notch in the edge of a thin piece of steel with a three-cornered file. Harden the steel if desired and shape the centers to the notch, which will be found to be pretty close to 60 degrees.

Only the tail-center should be hardened. The head-center is always left soft. The best way to true lathe centers is by means of a little emery grinder made especially for the work, and which can be attached to the slide rest or put in the tool post, and the head-center ground to shape in a very short time. The tail-center is ground by placing it in the head spindle for that purpose, after which it is returned to its proper position. With the center grinder there is no need of taking the temper out of the tail-center, but as we have no grinder the center must be annealed and slipped into the head spindle and given a blow to hold it in place.

Right here let me state that a hammer must never be touched to the lathe under any circumstances whatever. Get a copper hammer or one with a rawhide face, or cast one of lead or babbitt metal, and such a hammer must always be found among the lathe tools. If no hammer of soft metal is yet at hand, use a piece of wood and drive the center home with that. If the lathe has a compound slide-rest, set the upper screw to 60 degrees and turn the center by feeding the tool with that screw, by hand, of course. If there is no compound rest, set the side of a cutting tool to the angle desired—60 degrees—and feed the tool into a short bit of the center, deep enough to remove any places that must come out. Then move the tool along an eighth of an inch by means of the main and cross feeds and run in another short cut as deep as the first. Continue this until the center has been turned from

Fig. 5—Center Gage.

Turning a Center.

point to heel, then the use of a file and the gauge above described will soon bring the center to a proper condition for use. Fig. 5 gives an idea of this operation.

The tail center should then be hardened and the smith will need no instructions for that job, except that he harden and draw in the usual manner, leaving only the point of the tool hardened. A center is very apt to spring during the hardening operation, and this is one reason why it is necessary to test the

lathe for truth of centers every time a nice job is to be done between centers.

ADJUSTING THE SLIDE REST.

The next step in the lathe adjustment is the slide rest. It will be assumed that the various parts have been put in place, the handles put on the feed screws, and everything ready for use as far as the "smith-machinist" can see. To adjust the rest, see that the clips which hold the carriage to the ways of the lathe are so adjusted that the carriage moves freely when the proper handle is turned, but that there is not the least shake possible between carriage and lathe bed. The clips must be adjusted very close and kept well oiled and clean so that with the hardest possible work being done by a tool, there will be no shake or tremble between slide and bed as the former moves along the latter. This point is very essential and should be closely looked after.

SETTING GIBS.

Next, adjust the cross slides so that there can be no shake to the tool post. Underneath the cross-feed slide will be found one or more pieces of steel which are placed between the slides of carriage and cross feed. Several screws keep in place each strip of metal which is called a "gib," and which should be so adjusted by means of the screws that the tool post can be screwed from one end of its travel to the other, without going easy in one place and hard in another. This, as well as every moving or sliding part of the lathe, should be kept clean and well oiled at all times.

ADJUSTMENT OF SPINDLES.

The proper method of adjusting the head or live spindle of the lathe was described at the beginning of this chapter. The tail, or dead spindle, does not require as much adjustment, yet it should at all times receive care and oil, and should always be kept clean. To remove the tail center, screw the spindle back as far as possible and the inner end of center is forced against end of tail-stock screw, forcing the center from its seat. In some operations, tools will be fitted to the tail stock and it should be kept in mind that all such tools are to be so fitted that they may be readily removed by backing them against the end of screw as above described.

The tail spindle should be clamped by closing together, by means of a screw, the front portion of the tail stock. The lathe possessing a set screw in the tail stock for clamping the spindle is an antiquated affair and should not be in the possession of the smith-machinist. The tail spindle should be kept well oiled and very clean. When the lathe is in operation the tail spindle should be allowed to project as little as possible. Sometimes it is necessary to work with the tail spindle projecting a considerable distance, but whenever it is possible keep it within a half an inch or so of its most retracted position, for it is then in the most solid position possible and will stand much harder work without springing than when screwed out several inches.

CHAPTER IV.

PUTTING WORK INTO THE LATHE.

Don't try to get ahead too fast in running that new lathe of yours. If you are not accustomed to using a lathe, better follow the instructions closely and do not attempt to go in over your head before you can swim. You tried it once, when the lathe first came into the shop, and you were not at all satisfied with the result. It was something like this: As soon as the belt was on the lathe, you picked up the first piece of iron that came to hand and put it in the lathe. You hit each end of the iron with a center-punch, as near the center as possible, something as shown at A and B, Fig. 6. Then, after marking in that manner both ends of the iron, it was balanced between centers and the

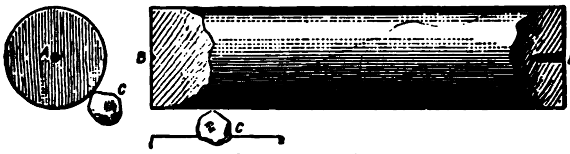


Fig. 6—Centering Work in the Screw-cutting Lathe.

lathe started on taking a cut along the iron. But you found it didn't work. The iron soon flew out of the lathe altogether and you then found the head-center to be pretty well out of shape.

The above is a sample of what happens when work is put between centers without being properly prepared. The right way is as follows: Mark both ends of the piece of metal as at A and B, Fig. 6; then put between the lathe centers and set them up against the work very lightly, so the work may revolve freely when turned by hand—simply rolled around by pressure of the hand, the lathe remaining at rest. Revolve the work slowly by hand as stated, and hold a bit of chalk close to the work as shown at C. Rest the chalk against the tool post, or otherwise steady it and press forward until the chalk touches the most eccentric portion of the work. If the chalk makes a mark nearly all around the work, then the centering has been properly done and the center

may be drilled as shown at D, a hole between 1-16 inch and 1-8 inch in diameter being drilled nearly 1-2 inch deep. A drill larger than 1-8 inch should not be used for center work except in very large work. Use small center drills.

After drilling, the work should again be revolved between centers by hand, for the drill does not always go where it is wanted and the centers may prove out of true when tested. The remedy for this is shown by Fig. 7, where the hole has proved to be out of center. With a very small half-round cold chisel the metal is chipped away on one side of the hole and a reamer inserted, the effect of the reamer being shown at G and H. The effect of chipping the hole is to draw the reamer toward K. If the slight chipping shown at E does not draw the hole far enough

Fig. 7—Truing Centers.

another chip may be taken from the hole shown at G and H, and the reamer again applied. After reaming it is well to use the drill again to make sure that the center will never touch the

Fig. 8—Correct Centering.

Fig. 9—Incorrect Centering.

bottom of the hole. Fig. 8 shows the hole drilled deeper than is necessary, but this does no harm unless there is some other work in the metal which forbids a hole in that place.

As stated above, correct centering, drilling and reaming is shown at J, where the lathe center fits perfectly into the hole in the end of the work-piece. By the way of contrast, a poor job of centering is shown in Fig. 9, where not only does the lathe center touch the bottom of the hole, but the reamer was too flat and the lathe center does not fit the hole made by the reamer.

Good lathe work is an impossibility when the centering is as shown in Fig. 9.

STRAIGHTENING AND SQUARING-UP.

When a piece of metal is centered as above and placed in the lathe it sometimes presents the appearance shown by Fig. 10 at L, M. True, the turning operation could be completed with the long and short sides on the work as shown at L, M, but if a great deal of work has to be done on the metal while it is between centers, it is extremely likely that the metal will wear off on short side M more than it does at long side of the center, thereby throwing the whole of the work out of alignment. To be sure, the wear would be slight, but on many lathe operations a shifting of the center even one one-thousandth of an inch would spoil the job.

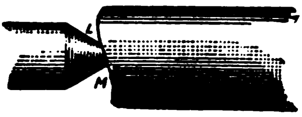


Fig. 10—Before Squaring.

In squaring the work a tool is fed in by hand as shown in Fig. 11, but soon strikes against the center O, and can go no farther. This leaves a hollow snag around the center, as shown at P. To get rid of the snag and leave the end smooth and square, the tail-spindle must be unclamped and run slowly back. At the same time the tool must be fed in by hand until it has cleaned off all the metal around the center, leaving it clean and smooth, as in Fig. 12. It may perhaps be necessary to state that the point of the tool should be just level with the center of the spindle during the squaring-up business. It will also probably be found necessary to clamp the lathe carriage so the tool cannot move away from the end of the work while it is being squared-up. Clamping is best effected by throwing in the lead-screw nut. Then the screw can be turned by hand until the tool is brought up to the work as far as necessary. Leaving the nut clamped during the squaring operation will effectually prevent the tool from moving out of the cut toward the tail-stock.

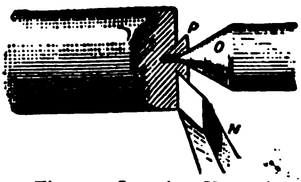


Fig. 11—Squaring Up.

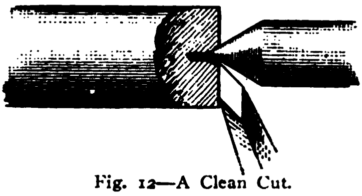


Fig. 12—A Clean Cut.

A word of caution is necessary in regard to clamping the carriage with the lead-screw. It is this: Never, in any case whatever, let the screw feed and the rod feed be in gear at the same time. If you do, an accident will surely happen, and sooner or later it will strip the teeth off some of the gears or do some other damage. Again: Never put rod and screw feeds in gear at the same time.

STRAIGHTENING LATHE WORK.

No matter how accurately the ends of a piece of work may be centered, the middle will often run out of true and cause a great waste of material in getting a fully turned surface the whole length of the work. Straightening is necessary when the above is found to be the case, and straightening should be done before the ends are squared up. If the piece be very crooked, it should be straightened by the eye as closely as possible, then put between centers, revolved by hand and the high places marked with chalk. Place the piece on the anvil, make it lie fair and strike as hard as may be thought necessary on the chalk mark with a hammer. Perhaps several blows may be found necessary and in some cases it is necessary to straddle the spot to be struck over the low space between face and horn of anvil.

When long pieces of shafting have to be straightened, a screw press is the proper appliance to use. The press should be mounted on wheels made to fit the ways of the lathe, then the press can be moved from one end of the work to the other, as there may be need of straightening. The smith will hardly have long shafting enough to turn to warrant the purchase of a screw press, therefore he must get along by peening. To use this method, which seems rather hard on the lathe, yet which will do no harm if properly used, the smith-machinist puts the shaft between centers and chalks the high places as before; then, with preferably a piece of wood three or four feet long, take a pry over a block placed on the lathe bed or upon the slide rest. Turn the shaft so that the lifting end of the lever will come exactly against and underneath one of the high-place chalk-marks, then with a rather light hammer, while a smart pry is taken on the lever, peen the low or hollow place in the shaft.

The result will be the stretching of the metal fibers at the point where it was hammered and by properly distributing the force and number of hammer blows, together with the power

placed on the lever, a fine job of straightening may be accomplished in nearly as little time as it takes to tell about it.

THE STEADY-REST AND ITS USE.

It will not take the machinist-smith long to find out that it is a pretty nice piece of work to turn a bit of iron and have it come round and straight. In fact, he will soon find that this is an impossible matter, and that he can only turn the metal "pretty near straight and round." This is a fact, and, while no piece of metal can be turned exactly straight and round in any machine tool yet invented or perfected, still the turning can be done plenty well enough for all practical purposes provided the necessary precautions are taken to insure good work.

"Why cannot perfect, straight and round turning be done?" Because the tool begins to wear the instant it begins to cut, and, constantly becoming shorter, turns taper instead of straight. The lathe and the tool as well spring more or less, and when a hard spot comes to the tool the lathe springs more than when the metal is soft, therefore there are "bunches" and "ribs" in the finished work. There are other things which affect accuracy in lathe work, but it must be considered that the errors are very small. Any good lathe can be made to work to and within one one-thousandth of an inch, and the ridges and bunches mentioned above can be kept down to the one-quarter of a thousandth if necessary, which hardly will be the case in any work likely to come into the smith-machine shop.

Try to turn a long shaft, and all goes well for about three or four diameters in length of cut, but after that the shaft springs away from the tool and good work is impossible. To turn long pieces in the lathe use must be made of the appliance known as the "steady-rest." This useful adjunct of the lathe is made to stand upon the lathe-bed and is clamped fast thereto by means of a bolt. The upper portion of the rest is split and hinged that it may be opened and placed around work already between centers. Then three pieces of steel are so adjusted that they each touch the shaft, after which the bolts holding the steel pieces are tightened up and the pieces in question form a bearing for the middle portion of the shaft, which prevents the springing due to the great length otherwise unsupported between the lathe centers.

Sometimes it is necessary to set up two steady-rests in order to do the work which has to be accomplished. Whether one or

two steady-rests are used, great care must be taken in setting them up to see that they are exactly in line with the spindles of the lathe. It is a pretty nice job to set up a steady-rest in the middle of a six-foot shaft and have everything in line. To thus set up the steady-rest, the method described for lining the centers must be used, a short piece of shaft being put between centers, the diameter of the short shaft being exactly the same as the long shaft to be worked, and the length such that, with the steady-rest in required place, the shaft will barely project through the steady-rest just far enough to receive the tail-center.

After testing up the tail-center, set up the steady-rest close to it, and adjust the three bearing strips snugly to the shaft close to the center, then move the tail-stock back to receive the long piece of shaft which is to have work done upon it. The smith-machinist must not get the idea that he can turn a long piece of shaft accurately by supporting it in one or two steady-rests between centers. For turning shafting of any length beyond three or four feet a different arrangement, a modification of the steady-rest, must be used. This appliance is known as a "back-rest," and is attached directly to and moves along with the slide-rest. It is usually a plate, carrying a hole, through which the turned shaft passes snugly. The cutting tools are fastened to the front side of the rest, and the shaft must pass the tool or tools (there are usually two, a roughing tool and a finishing tool) before the same portion can go past the back-rest. The rest thus forms a sort of bearing, which remains constantly at the point of cut, the result being that the shaft is supported close to the cutting tool along the entire length of the shaft. The bearing in steady- or back-rest should always be kept well lubricated, likewise the tail-center of the lathe.

In doing many kinds of work—the cutting-off and threading of large steam pipe, for instance—it is sometimes necessary to remove the tail-stock from the lathe and use the steady-rest instead. The other end of the work being held in a chuck, both centers being dispensed with, the pipe can be cut off and the end threaded at will. In thus using the steady-rest, it is necessary to provide a smooth, true surface for the three steel strips to bear against. For this reason it is often necessary to carefully file a portion of the work that the steady-rest may have the necessary bearing. When the work is very rough, or some other

section than round, it becomes necessary to provide an artificial surface for the steady-rest to bear against, which may be done by slipping over the work a sleeve which has been turned smooth on the outside. The sleeve carries eight set-screws—four at either end, spaced 90 degrees. Slip the sleeve over the work true, by means of the set-screws, and adjust the steady-rest to the sleeve.

THE BACK-GEAR AND ITS USE.

The use of the back-gear is two-fold. It is for the purpose of supplementing the step-cone when arranging the speed of the work, and for enabling the small belt to give sufficient power to take a heavy cut off a large diameter. When turning metal in a lathe there is a certain speed which gives the best results for steel, another speed at which brass works the most economically, and still another speed at which it pays best to work cast iron. The smith-machinist has all these speeds to learn, and the use of the step-cone and the back-gear is to obtain an approximation of these speeds when working one of the metals in question.

This means that the surface of the work in a lathe must travel at the speeds indicated; therefore the speed of a lathe must be governed entirely by the diameter and kind of material which is being operated upon. If a 2-inch piece of soft steel is being worked—circumference 6.282 inches or 0.523 foot—be put into the lathe, that piece of metal must revolve at the rate of about 95 revolutions per minute in order that the surface of the metal may travel 50 feet per minute. Should the work chance to be 4 inches in diameter, it must needs revolve only one-half as fast, or about 45½ turns per minute, in order that the speed of 50 lineal feet per minute be maintained. This means that the speed of the lathe must be reduced one-half. If the necessary reduction of speed cannot be obtained by means of the step-cone, the back-gear must be used. In a future chapter the proper speeds for various kinds of work will be discussed and the various speeds possible by means of step-cone pulley, both with and without the back-gear, will be given in full, as adopted by some well-known lathe builders.

CHAPTER V.

THE TOOL POST AND ITS USE.

Next to a good tool, the tool-post of a lathe is about as important a part as is contained in the whole machine. A tool-post too light or with an insufficient screw cannot be made to hold the lathe tool as stiffly as is necessary and the result will be a weak, chattering cut, which is a sure preventive of good work. Not only should the post be strong, but it must also contain means for quickly and easily adjusting the point of the tool to any required height. There are several methods of tool adjustment in use among lathe builders, but the one illustrated by Fig. 13 is as good, if not better than any of the others.

Referring to Fig. 13, which is partly in section, a piece of work is shown at A, which is supposed to be in the lathe. The

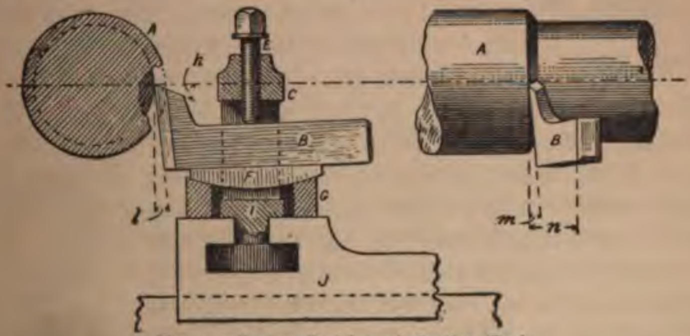


Fig. 13—Proper Position of Cutting Tool.

tool B is in place with its cutting point or edge as close as possible to the longitudinal or axial center line of the lathe. A new tool has a long vertical point to allow of wear in grinding the tool, consequently a new tool will stand high above the center line and will have to be tipped down as shown at A, Fig. 14. When the tool is about worn out it must be tipped up as at D.

Referring again to Fig. 13, the tool-post I is shown in place with the screw E bearing upon the tool. Incidentally, a close watch should be kept over the end of screw E, and if there

be the slightest sign of any spreading or upsetting the end should be hardened at once. The test is, to see if the screw will back out through the nut which is formed in the upper portion of the tool-post. As long as the screw will come out easily all is well, but the instant the screw begins to stick attend to it at once.

COLLAR AND WEDGE ADJUSTMENT.

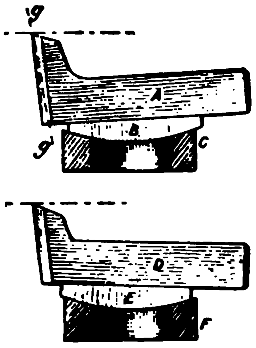


Fig. 14—Adjustment of Tool by Means of Collar and Wedge.

The tool-post C, Fig. 13, is mortised to carry a tool much larger than the one shown in place. When work has to be done at a distance from the tool-post, as in deep channels, between collars, etc., there is need of a long tool overhang, therefore the tool-post must have a hole large enough to receive the large tool section necessary for supporting the necessary overhang. The upper portion of the slide rest is sometimes called the "anvil" and is shown at J. An undercut groove is made in this part of the slide rest, to receive the lower end of the tool-post as shown. Between the "anvil" and the tool is a wedge F and a collar G, of peculiar construction, as will be later described and shown by Fig. 15, the upper portion of the collar being turned concave to fit the bottom of wedge F, Fig. 13, and more clearly shown by Fig. 16. The bottom side of the wedge is finished to fit the concave surface of collar and the upper surface of wedge is tooled or cut like a file to prevent slipping of the lathe tool, which may be screwed down against it. The wedge F, Fig. 13, is just wide enough to go freely through the mortise in the tool-post. The collar G is usually made about two and one-half times the diameter of tool-post and of varying thicknesses, according to the size of the lathe. By moving endwise the wedge F the point of the tool is raised or lowered so as to coincide with the center line of the lathe. The action of the wedge is more clearly shown by Fig. 14, where the newly forged tool is shown with its long neck at A, the wedge B having been pulled back on collar C, to bring the point

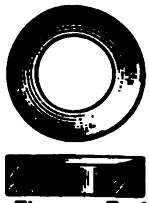


Fig. 15—Tool Post Collar (Plan and Sectional Elevation).

of tool to center line of lathe. As the tool is ground off during use the shape approaches that shown at D, the wedge E having been pushed forward on collar F, so as to maintain the cutting edge of the tool on the center line of the lathe as before.

"CLEARANCE" AND "RAKE."

Fig. 13 shows the tool set with point on center line and a certain angular distance between the end of the tool and the vertical tangent of the surface being cut. This distance is marked 1, and varies in different kinds of work and will be discussed later. For present purposes it will answer to give just enough clearance so the tool does not rub against the piece of metal to be turned, say about 3 degrees for steel, wrought iron and brass, and 4 degrees for cast iron. The "clearance" is sometimes called "bottom rake," but the first name is the better one.

Fig. 16—Tool Post Adjusting Wedge.

The "rake" of the tool is the distance k, from the line of the tool to the cross-center line of the work in the lathe. It is better to call the distance k the "top rake," which is about 22 degrees. This angle, added to the clearance of 3 degrees, makes a total clearance of 25 degrees, which subtracted from 90 degrees leaves 65 degrees, the "cutting angle" of the tool shown in place by Fig. 13. For steel and wrought iron the top rake may be as above, but for cast iron the top rake had better be diminished to about 15 degrees, thereby giving a cutting angle of 72 degrees. For brass the angle should be still slightly increased to about 80 degrees, which with a clearance of 4 degrees leaves 76 degrees rake or top clearance.

A tool, in order to feed properly along the work, must have another form of clearance as shown at m, Fig. 13. This form of clearance is called the "side clearance," which should be very small, probably not more than the bottom clearance of 4 or 5 degrees. In some types of tools, as shown by Fig. 13, side clearance may be given a tool by swinging the tool sidewise the distance n, which turns a part of the end clearance into side clearance. The tools which can be used in this way are not many, They are the "front tools" like round-end brass or cast-iron turning tools and cutting-off tools, which make good ones for finishing, if ground off a little on one corner. Such tools can be given

a little side clearance by turning them slightly as shown at n, Fig. 13.

FORMS OF SIMPLE LATHE TOOLS.

Several ordinary forms of lathe tools are shown by Fig. 17. These tools may be purchased in "sets" as above, all sharpened, ready for use, at a cost of $2 to $3, but in a size too small for use in the smith shop. The steel from which these small tools are made is about 1¼ x ½ inch and they are from 2½ to 3 inches long. Of course these tools may be purchased in the size needed, but they will cost a good sum of money and there are several

Fig. 17—Common Forms of Lathe Tools.

tools among them which will not be needed for a long time in the kind of work the smith is likely to do.

The argument for buying the small tools is to keep them for patterns and forge tools from ½ x 1 inch steel, making them just like the small ones, except for size. Furthermore, the small set of tools may be kept at hand to serve as models for grinding the larger tools, at least until the smith has "learned the trade" far enough to know why he gives a certain shape to a certain tool in order to obtain certain effects in the lathe. The ½ x 1-inch tools may be purchased for about $5.

Directly in line with this matter is the arrangement of the tool as shown by Fig. 14. Here the tool is tipped more or less by means of the sliding wedge in order to keep the point of the tool on the center line of the lathe. It will be noted that as the point of the tool is tipped downward, the clearance becomes greater and the top rake less. To a considerable extent this matter regulates itself, for as the tool is ground away on top it is natural for the "machinist-smith" to also grind off the face of the tool as shown by the dotted line g, to which point the grinding will probably have progressed by the time the tool is ground down short as at D.

Grinding off the front of the tool increases the clearance when the tool is low, and grinding off the top of the tool decreases the clearance in about the same ratio, therefore the clearance remains practically the same, the smith noting when the tool does not have quite clearance enough, and correcting that matter the next time he grinds the tool.

Referring to Fig. 17, the names and uses of the several tools are as follows: Nos. 1, 2, 3 and 4 are what is known as "side tools." They can be used for almost any kind of exterior turning, but they may be classed as "old style" tools, as they were used a great deal more fifty years ago than at present; still, for many kinds of work these tools are not equaled by any other form of tool made.

Nos. 5, 6 and 7 are "diamond points," and are used for general work, heavy and light. Nos. 8 and 9, "half diamond" and "round nose," for turning cast iron and brass. No. 10 is a "water finishing" tool. No. 11 is for "cutting off" and is made in different widths, as will be described later. Nos. 12, 13 and 14 are "thread" tools; No. 13 is for roughing or taking the first cuts, No. 12 for finishing the threads and No. 14 is a bent thread tool for getting into corners. No. 15 is an "inside" thread tool for cutting threads inside of nuts and other work, and No. 16 is a boring tool for working inside surfaces.

PROPER SETTING OF LATHE TOOLS.

Although a tool may be made to work in almost any way, however it may be put into the tool-post, there is a certain way whereby the tool does better work than if set some other way.

Fig. 18 shows a tool improperly set to do good work, especially in the heaviest cuts that can be taken by the lathe. As shown by the engraving, the tool is feeding in the direction of the arrow, but bears against two edges of the tool-post at A and D. The tendency of the cut, especially if very heavy, is to push the tool around in a direction from A to B, and the other end of the tool goes from D to C.

In setting a tool always remember this tendency of a tool to swivel under the tool-post screw, and to prevent that action set the tool to bear against B and C and there can be no swinging of the tool either into or out of the cut.

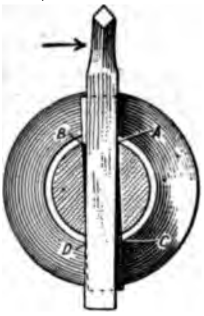


Fig. 18—Tool Improperly Set in Tool Post.

Fig. 13 gives a clue to the proper setting of almost any lathe tool as far as height is concerned for all tools must be set in that manner, but otherwise the tools must be differently set according as they are to take heavy metal removing or light finishing cuts. Nos. 1, 2, 3 and 4 should all be set for straight turning as shown by Fig. 19, the heel or shank of the tool going first, so that the tool makes a "pulling" cut instead of a pushing one, as is the case with the diamond points 5, 6 and 7, Fig. 17, which are all end-cutting or "push" tools.

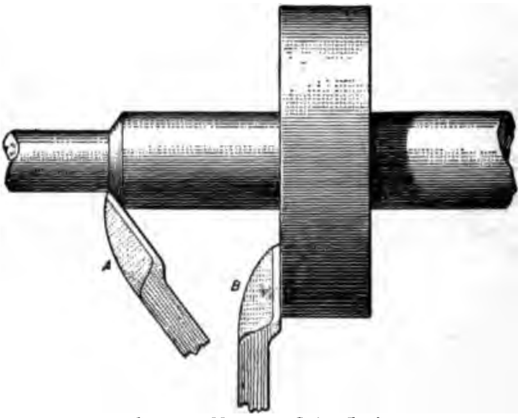


Fig. 19—Uses of Side Tools.

The method of setting the tool in the post as shown by Fig. 18 applies to the side tools fully as much as to the diamond points. For heavy cuts that setting of the tool is very necessary,

but for finishing and other light cuts it may be neglected, still it is an excellent way of setting a tool of any kind, for any cut. The proper method of setting the diamond point tools was fully illustrated by Fig. 13, and the roughing and round nose tools 8 and 9, Fig. 17, should be set in the same manner as more fully shown by Fig. 20.

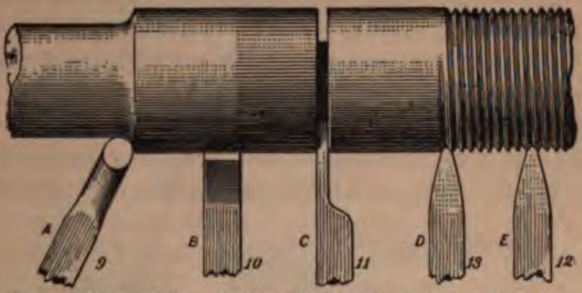


Fig. 20—Uses of Round Nose, Cutting-off and Thread Tools.

The method of setting the boring tool and the internal threading tool is shown by Fig. 21 at B and A, respectively. A more comprehensive view of these tools may be had at D and E, Fig. 22, where the proper setting is shown in plan and in the end view. It will be seen from this engraving that the tool is always set on the center and that it is ground to give about the same clearance and rake no matter what kind of a tool is being used or where it is to be set. Let the "smith-machinist" once get this matter well fixed in his mind and he will have no trouble in grinding or setting any tool to take a clean, smooth cut.

The method of setting the water-finish tool is also shown by Fig. 20, as also is the setting of the cutting-off and thread tools.

Fig. 21—Boring and Inside Thread Tools.

The water finish tool 10 is set square against the work, but the corner which is to be fed in advance is ground back a little. This will be more fully shown in Fig. 22. The cutting-off tool is set in exactly the same manner as the water-finish tool. In fact, there is little difference between the two tools, and one may be

used in place of the other to advantage. In the engraving the cutting-off tool is shown very narrow, but its width is merely in accordance with the depth of cut to be made. Cuts only a half an inch or so deep may well be taken with a tool only 1-16 inch wide, while cuts 2 inches deep should have at least 3-16 inch width of tool to enable them to stand up to the work.

As regards the width of a tool necessary for a water-finish cut, there is nothing arbitrary about the matter. It is only necessary that the tool is more than twice as wide as the width of cut taken by the lathe—width of cut, not depth. Fig. 22 illustrates this matter, also the grinding back of the advance cutting corner of the tool as noted in the preceding paragraph. No matter what the angle at which the face has been ground, place

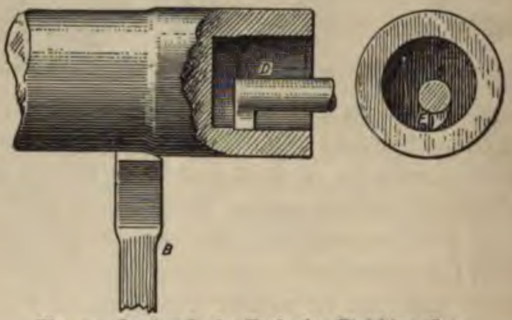


Fig. 22—Setting Lathe Tools for Finishing Cuts.

that face square against the work and let the shank of the tool point in whatever direction it may.

The same is true of the water-finishing tool. Fig. 22 at B shows how the advance corner is ground away and the remainder of the tool set square against the work. Water should be supplied all the time when taking a finish cut, either by hand, from a squirt can, or from a can with a small hole therein, suspended above the work and arranged to feed along with the slide rest. Soda water, soap suds, or any similar substance may be used, but plain water is all that is needed. The water-finish tool, ½ inch wide, is wide enough to stand ⅜-inch finishing cuts. The smith lathe will never be called upon to make finishing cuts more than 1-32 inch wide, therefore the narrowest cutting-off tool is wide enough for a water cut.

Bear in mind that the whole principle of finishing cuts, as

noted above, depends upon a "double-line" cut. This is shown plainly by Fig. 22, where one portion of each tool is ground to bear against the finished work, while the other portion of the tool is cutting down the metal ahead of the tool. Arrange every finishing tool in this manner, and a good clean cut will be the result, no matter what kind of a tool is being used. The rule applies to every form of tool, inside or outside.

The thread tools must in every case be set square against the work and inclined neither back nor ahead. The thread tools are sometimes bent to enable them to be set easier in the tool-post, as in tool 14, Fig. 17, and this is also true with the other bent tools; side tools 3 and 4 and cutting-off tools and diamond points are frequently bent to permit their use in some corner of work which cannot be gotten at with the ordinary form of tool.

The roughing and finishing thread tools are applied as shown at D and E, Fig. 20. A roughing tool is used for the simple reason that it is impossible to keep the point on a sharp thread tool when roughing out the first portion of the thread. Frequently the machinist uses a single tool and grinds off the point when he does the roughing, but this makes another grinding necessary when the finishing cut is to be made, and is an expensive way, hence the use of the roughing tool 12, Fig. 17, and D, Fig. 20, which also shows the setting of the thread finishing tool at E.

CHAPTER VI.

DEPTH OF CUT.

When taking a plain cut, one of two things must be the object: either to remove a lot of metal, or to obtain a finished surface on the metal which is being operated upon. It is not good policy to use a larger piece of metal than is necessary, for removing metal in the lathe is a costly operation. It is much better and less costly to do the metal removing in the forge and leave just enough metal to finish to size—and this is where the good smith comes in, for the writer has seen some of the latter craft who could forge fully as close as some machinists could work with a lathe!

When metal must be removed—and frequently it has to be done, no matter how close the forging—set the tool to take as thick a cut as the lathe (or the work) will carry. It takes much less than double the power to run a cut ⅛ inch deep than it does to run a cut 1-16 inch deep, for the lathe friction is the same in both cases. Use a stiff tool and grind it in such a manner that it turns out a smooth continuous chip when cutting wrought iron or steel. The continuous chip business cannot be done when cast iron or brass is being worked, but the chip is always the test for the condition of a tool when cutting wrought iron or steel.

Never try to work with a dull lathe tool (or any other tool). It requires too much power when removing metal and a dull tool never gives a good surface when finish is required. Never let a tool go until it needs a lot of grinding, and never grind a tool temporarily—that is, never sharpen just the point, so that the job can be finished in a hurry. Such a course never pays. The time saved in temporary grinding is more than lost by trying to make a poorly fitted tool do the work. Grind from the bottom of a tool, every time, and grind as well as you know how. It pays.

THE PROPER SPEED.

"How fast should a lathe be run on various kinds of work?" is a question which has many times been "fired" at the writer,

and the same answer must be given every time, to wit: Run the lathe as fast as the tool will stand it. Old-time machinists used to run lathes much slower than the present practice calls for, and speeds of 20 feet per minute were often found. In many shops, the speed for turning gray cast iron lies between 32 and 100 feet per minute for first or scale cuts; 40 and 130 feet for second cuts, and 70 to 250 feet per minute for finishing cuts. But these speeds are much greater than the smith will ever use for work that will come to him, therefore the several lathe speeds will be calculated for or at 20 feet per minute.

The writer is not aware of the kind of lathe possessed by any particular reader, therefore he is unable to use the exact diameters of the step pulleys or to figure exactly the speed at which the lathe will run with the belt upon any particular step with back gear in or out, but, for example, will take the data of a certain lathe which has step pulleys as follows: 4¾ inches, 6½ inches, 8⅛ inches, 10 inches and 11¾ inches in diameter. The pulley on the counter shaft has steps of exactly the same diameters, and, as shown in Fig. 23, the gear on spindle has 30 teeth, meshing into a gear of 90 teeth on the back gear, which also carries another gear with 18 teeth, which engages a gear with 72 teeth on the lathe step pulley.

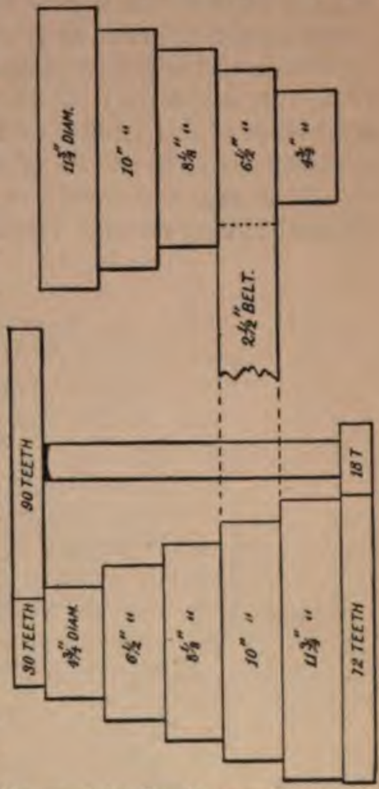


Fig. 23—Lathe Step Cones and Back Gear.

Thus the ratio between the pulley and the spindle when the back gear is in use is 12 to 1, and the spindle speeds are as follows: With belt, 371, 231, 150, 97.5, 60.6 revolutions per minute, the counter shaft running at 150 revolutions per minute. With back gear in use the speeds are: 30.9, 19.25, 12.5, 8.1 and 5.05

revolutions per minute. The ratios between cone step speeds are as follows: 1.60, 1.54, 1.53 and 1.60, and the ratio between the belt and gear speeds is 1.96.

With the data given above we can figure the speed at which the spindle should be made to run to give as near 20 feet per minute as possible to the work in the lathe. The method is something as follows: The work is 10 inches in diameter. What step should the belt be placed on to drive the work 20 feet per minute, or as near that speed as possible? $10 \times 3.141 \div 12 = 2.62$ (slide rule calculation), which means that the work has a circumference of that number of feet. Divide 20 by 2.62 and the quotient is 7.64, the number of revolutions per minute the spindle should run to give the surface of a 10-inch cylinder a velocity of 20 lineal feet per minute. From the data given above it is found

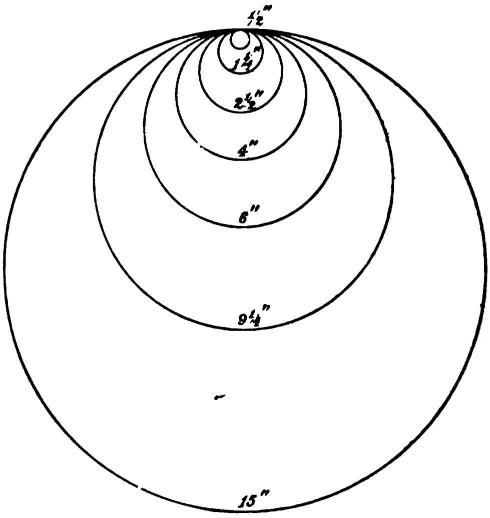


Fig. 24—Diameters of Work Giving 20 Feet per Minute Velocity.

that the nearest speed is 8.1 revolutions per minute, which is given when the back gear is in mesh and the belt is on the step next to the largest. The revolutions are 8.1, hence the surface travel will be $8.1 \times 2.65 = 21.45$ feet per minute, nearly.

Fig. 24 gives a graphic representation of the different diameters of work which will give exactly 20 feet per minute cutting

speed. The smaller sizes are not given, as the circles would be too small to distinguish. The smith-machinist will do well to make up a similar set of circles, either full or half size, and keep them near the lathe until he becomes accustomed to obtaining the proper speed of revolution for any work he puts in the lathe. After a time the circles will not be needed, for the right velocity will come instinctively and without any apparent effort on the part of the operator to study it out. For the present, however, make a set of "Velocity Diameters," and draw circles to them. They will come very handy.

The tendency of machine shop practice is to as great speeds as the lathe tools will stand up under, and the 20 feet per minute rate of feed is hardly ever found in practice nowadays. Still, for the beginner at lathe work, it is an excellent speed to follow. In a paper recently read before the Cincinnati Metal Trades Association, the result of over 400 records of routine turning was tabulated, and it was shown that for turning gray (cast) iron, the speed in feet per minute varied from 32 to 115 feet for roughing cuts, or 35 to 135 feet for second cuts, and from 70 to 240 feet for finishing cuts. For machinery steel the speeds given are considerably higher, ranging from 40 to 163 feet for roughing, 45 to 150 feet for second cuts, and from 68 to 390 feet per minute for finishing cuts. It is stated that the tools stood up to this usage for different periods of time, ranging from 2½ minutes to half an hour. It is not expected or recommended that the smith-machinist will attempt the higher speeds. When the smith gets so that he can make a tool stand up under them he may be assured that he knows how to forge a good lathe tool, also how to grind and set that tool exactly right.

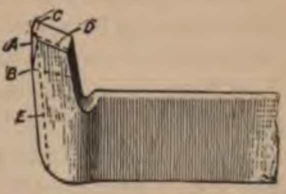


Fig. 25—Point of Tool Worn Off.

Probably the early attempts to work a lathe tool at high speed will prove very disappointing, and the tool, after a few minutes' use, will appear something as shown by Fig. 25. Always be on the lookout for a thing like this and never let a tool get into such a condition. If such use is permitted, the tools will soon be very scarce in the shop. Realize what it means to have a tool worn off, as shown at A, Fig. 25. It means that fully one-third of the effective cutting metal in the tool must be ground off

and wasted before the tool is fit for service again. To grind this tool, two courses are open: Either the top of the tool must be ground off down to the line B, or two sides of the tool must be taken down to the lines C, D and E. The first method is the best, for less metal will be wasted on the grindstone or emery-wheel, but the tool will need reforging quicker than if it is ground off on the vertical faces, C and D.

The lesson to be learned from an occurrence of this kind is: Never let a tool get as dull as shown by Fig. 25. The time to grind a tool is as soon as any appreciable wear appears at A. A tool cannot get into this condition without first becoming slightly rounded on the cutting edge, a condition which immediately becomes manifest by the chip becoming rough and lumpy, more heat being manifest between tool and work, and by symptoms of distress manifest generally by the lathe and by the belt in particular.

Too fast a speed is frequently made manifest by a tool taking the shape shown in Fig. 25. Indeed, distress is always manifested by the tool when the cutting speed is too high, although similar results are sometimes obtained at the tool point by improper tempering and by poor shaping or grinding. Sometimes the novice grinds the tool so fast on an emery wheel that the temper is run out of the point of the tool, which immediately wears off to look like Fig. 25. The operator will soon learn to distinguish between trouble caused by too much speed and that due to too soft a tool.

ROUGHING AND FINISHING CUTS.

In setting a tool for a roughing cut, the point of the tool should always be protected by being made to run in clean metal underneath the outer scale or skin of the work. In roughing cast iron there usually is more or less sand adhering to the metal, and if the point of the tool is made to scrape through or against such scale, the grindstone will be in more use than the lathe. For roughing cuts, the tool should take a cut thick enough to make sure that the tool works below the scale. Then, only a thin edge will come in contact with the scale, and where that edge does come against it, the scale has been broken or torn away by the wedge-like action of the point of the tool which is slightly in advance of the portion of the tool which cuts the skin.

Fig. 26 shows the proper setting for a roughing cut in cast iron, the round nose tool being used. The advanced point of the tool B cuts in clean metal and does not come in contact with scale, which only can come in contact with the tool at C, and

Fig. 26—Taking a Roughing Cut.

even then, as stated in the previous paragraph, the advance portion of the tool at B serves as a wedge to open up the chip, breaking it away from the uncut metal, so that in reality there is very little cutting actually done by the tool at C.

Second and finishing cuts have no scale to contend with, therefore the tool can be set to cut on the surface as much as is necessary. In fact, no attention is paid to the surface of the work when setting a tool for a second or for a finishing cut. The tool is placed to bear fair against the finished surface only, leaving the matter of the rest of the cut to take care of itself.

WATER CUTS.

As stated elsewhere, a particularly fine finish can be obtained on a turned surface by keeping the tool and the work wet with water or some other substance. The reason why the tool cuts cleaner when wet is that the water or other substance serves as a sort of lubricant to the tool and enables the tool to cut with less expenditure of energy than when it is not lubricated. An instance is the use of oil when chipping wrought iron with an ordinary cold chisel. The oil lubricates the cut so the chisel perform its work easier, therefore cleaner, than when used dry.

Another reason for using water on a finishing cut is that the

heat generated at the cutting line is carried away by the water, enabling the tool to keep cooler and therefore retain its edge a much longer time. Not only does the water carry away a portion of the heat generated by direct increase in temperature of the water flowing over the cut, but much more heat is absorbed by a portion of the water being turned into steam at the point of cut. This is the real source of cooling and it probably has a good deal also to do with the quality of the finished surface.

USE OF SODA WATER AND OF OIL.

In some shops, pure water is used for finish cuts; in other shops, a sort of soda water is used. Again, other shops make use of soap suds, while other shops use oil. Any of these substances will enable a lathe tool to take a much smoother cut than it is capable of when dry. Oil is not a good substance to use on finishing cuts, or on any other lathe-work except polishing. Water is the best. Soda dissolved in the water does three things which are beneficial. Soda water is a better lubricant than pure water and has more the nature of oil, thereby reducing slightly the friction of the tool against the work. Soda water has a higher boiling point than pure water, thereby enabling the water to become heated hotter before it is flashed into steam by the heat generated in cutting iron. Third, soda water will not rust the work as pure water will, the alkaline solution holding the oxygen of both water and air well in check, therefore soda water fills the bill as a water-cut material. Many other substances will help make as smooth a cut as soda—salt, for instance, will do as well as far as cutting is concerned, but the manner in which a salt solution will let oxygen act upon the surface of iron or steel forever prevents the use of salt water for making finishing cuts.

In this connection, it may be well to call attention to the fact that there are liquids which, instead of acting as lubricants when applied to cutting tools, seem to aid the tools in taking hold of the work. Spirits of turpentine, applied to a cutting tool, helps to cut material which, without the liquid, the tool could not touch. Substances like glass may be turned or drilled if the tools be kept wet with turpentine, benzine or similar substances. But they do not make the tool cut smooth, hence they are worthless for use on finishing cuts.

CHAPTER VII.

FILING WORK IN THE LATHE.

The proper method of setting tools for finishing cuts was described in Chapter VI. and only practice in accordance with the directions there given is necessary to enable any good workman to turn out work with a smooth finish which is accurate to size as well as of good appearance. When it is not convenient to take a water cut over the work, a finished surface may be obtained by first filing the work in the lathe, after which the surface is ground with emery and then polished by any adequate substance like chalk or clay.

When it is decided to file up a piece of work in the lathe with a view of ultimately giving it a high polish, a good deal of attention must be given to the selection and use of the file. A coarse file should never be touched to work between lathe centers for the purpose of preliminary polishing work. If there is material enough to be removed to warrant the use of a coarse file, then take another light cut with the lathe tool and remove the superfluous metal.

All the filing that should ever be done is sufficient to remove the tool-marks, and the skillful workman will see that these marks are very slight. Nothing coarser than a mill file should ever be touched to the work and then that file should be used lightly and sparingly. Remember, that as soon as filing commenced, the work begins to depart from a true cylindrical form and becomes more or less irregular in section—the more it is filed, the more irregular will it become.

The first stroke of the file means that flat places are being made, therefore it is advisable to speed up the work so that a single stroke of the file will reach at least entirely around the object being filed. For very small work, the highest speed may be used for filing and larger diameters should have the speed reduced in proportion. A ten-inch shape should revolve at least 60 revolutions per minute for filing purposes. The file should be applied lightly, and with a steady pressure, and moved slowly

against the work. Never give the file a quick jerky motion while filing in the lathe—or anywhere else, for that matter.

HOW TO HOLD A FILE.

See that there is a firmly fitting handle on the file. Never use a file without a handle—and grasp the handle with all the fingers of one hand, then take the tip end of the file between the thumb and forefinger of the other hand. Bear lightly against the work and push the file lightly and evenly along so that its whole length, from point to handle, comes in contact with the work. In selecting a file, sight along the sides and see that there are no short crooks in the file. A file which is full of hollow places and bunches is not fit for lathe filing. If you have been caught into buying such a file, use it for something other than finish filing in the lathe.

If the file is new, dip it in gasoline or naphtha to remove every trace of grease. Brush the file with the file-card to make sure that no grease remains in the bottom of the cuts. As soon as the gasoline evaporates, rub some chalk over the file. The chalk will fill the spaces between the teeth and prevent the file from filling up or clogging with metal filings. While the file is clean, it can be pushed with a smooth easy motion along the revolving work, but as soon as one or more particles of metal stick between the file teeth, a roughness will be felt in the advance of the file as it rides over the obstructions between the teeth. The result will be bad scratches in the work where the caught filings tore their way along the surface of the work. Just as soon as the least roughness is felt in the advance of the file, clean it with the card and rub in some more chalk before taking another stroke.

It is impossible to do good work with a dirty file, and never a stroke should be taken when the feel of the file shows that some of the teeth have become clogged up. File "cards" are on sale in the hardware stores. They consist of a piece of wood conveniently shaped for the hand, with a bit of "card clothing" tacked upon the board. The "clothing" is a piece of leather filled with fine wire steel teeth which project about ⅜" from the leather. Rub this appliance hookwise in the direction of the angle on which the file was cut and it will clean out all the foreign material which may be lodged there, with the exception of some bits of metal

which have become hammered between the teeth too strongly to be removed by the brush-cleaner. These bits of metal are what cause trouble when filing. To remove them, take a sharp pointed awl (a horseshoe nail will do, if nothing better is at hand) and

Fig. 27—"Picking" a File.

push it sharply along the channels between the file teeth. A vigorous application as described will remove the most obstinate bits of metal. The application of chalk prevents, to a certain extent, bits of metal from becoming wedged between the teeth of the file. Fig. 27 shows how the bits of metal are taken out.

EMERY CLOTH AND ITS USE.

After the tool marks have been removed with a file technically known as a "mill" file, use a finer file of the cut known as "smooth." There is a still finer cut of file, but it does not pay to bother with it in finishing lathe work. Emery paper will do the business quicker than a file and at the same time will keep the surface more nearly cylindrical than is possible by filing.

Wrap the emery paper or cloth around the work in the direction the lathe is running, then press upon the paper with one or both hands and the paper will get in its work. Use paper a little finer than the file, and as soon as the file marks disappear use still finer paper, changing to still finer emery as the coarse marks disappear. In a few minutes a dull gloss will appear on the surface of the metal and the finish may be increased by the continued use of the last piece of emery cloth until it becomes filled with metal from the work being polished. Then the emery can cut less and the metal chips act as a sort of burnisher to polish the work.

If a very high polish is required, the emery paper may be replaced with rotten stone and later by crocus powder, which will give the work a surface as smooth as can be obtained. Bear in mind that it is of no use to try to polish a rough surface. Such an attempt will only polish the high spots, while the low places remain as rough holes among the highly polished high spots. A true surface must first be obtained before polishing can be effected. This is gained by the filing and emery papering described. As the carriage painters put it, the surface must be made "level" before it can be finished with even a decent polish.

GRINDING WITH EMERY WHEELS.

Some people entertain the idea that a polish can be given to metal by means of emery wheel grinding, but nothing can be further from the truth. The object of emery wheel grinding is to obtain a true surface, either flat or cylindrical, not to put a polish on the surface. True, a surface can be obtained by successive treatment with finer and finer graded wheels, and a finishing touch with rouge on a rag wheel, which will impart a splendid surface to the work, but that does not constitute emery grinding with wheels.

Probably all the wheel emery grinding which the smith machinist will have anything to do with, is the placing of an emery wheel upon a fixture which is held in the tool post of the lathe and driven from a drum overhead, the work being revolved at a slow speed while the emery wheel is traversed back and forth along it.

The principle of a tool post rig is shown by Fig. 28, and the smith can easily rig up the necessary apparatus for himself, or he

can purchase the entire outfit ready made. Briefly stated, the device consists of the emery wheel A, attached to the arbor of the tool-post bearing B, which is so shaped that it is put into the tool post exactly as if it were an ordinary tool. The bearings

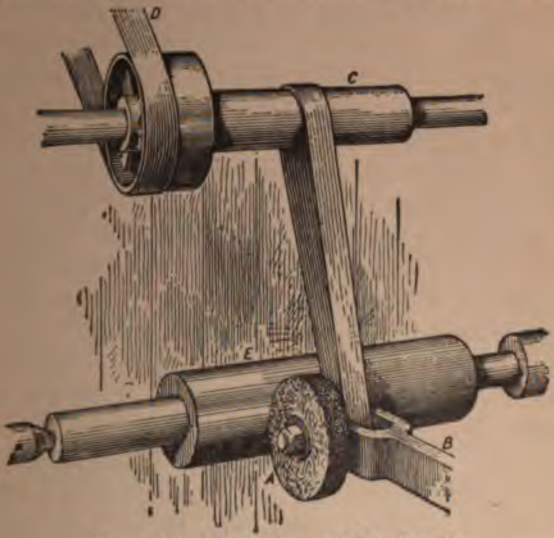


Fig. 28—Tool Post, Overhead Grinding Rig.

are fitted with oil cups and an adjustment for wear. The drum C is mounted overhead, independent of the lathe counter, and is driven by its own belt D; tight and loose pulleys being supplied for starting and stopping the drum.

The object to be ground, E, is put between centers exactly as for turning, and especial care is taken that the centers are in good condition and well fitted to the work. In grinding, it is necessary that the wheel always traverses entirely past the end of the work. If the wheel is reversed before its width passes entirely off the end of the work, true grinding is impossible.

KEEPING EMERY WHEELS IN ORDER.

In order to do good grinding it is absolutely necessary that the emery wheel be round and free from all low places, hard lumps, or glazed spots. If the wheel runs the least bit out of true it must be rounded up before a decent job of grinding can be done. To dress an emery wheel a diamond tool is an absolute necessity. No other appliance will take the place of the diamond

for this service, and a diamond tool costing two or three dollars will, by careful use, last for years.

With a diamond tool, the emery wheel can be turned as if it were a section of a turnip or some other soft material, so easily does the harder diamond take hold of the hard emery. Keep the diamond handy to the emery wheel, no matter whether you are going to grind a piece of steel for a fit within a quarter of a thousandth of an inch, or whether you are going to sharpen the chilled point of a plow. It is just as necessary that the wheel run true in one instance as in the other, and the quality and quantity of the work turned out in either instance is in direct ratio with the condition of the emery wheel, other things being equal.

To true up an emery wheel, put a solid bearing within a quarter of an inch of the wheel and rest the diamond tool firmly on that rest or bearing and turn up the wheel as if it were a piece of wood in a speed lathe. During the turning process the emery wheel may run at its full regular speed and need not be slowed down for truing up.

In selecting a diamond tool, pick out one from which the handle may easily be removed, then when an extra nice wheel is required the tool minus its handle may be put into the tool post of the lathe and the wheel dressing done in short order. In emery grinding for accuracy of diameter and surface, and that is what is desired in this kind of emery work, bear in mind that an object like a roll or a wheel which is to be made to run accurately in bearings cannot be accurately ground on centers.

For instance: if it was desired to make the emery grinder as true as possible it would not do to put the wheel on its arbor between the lathe centers and grind the wheel thus. It would be extremely probable that the wheel would not run true when it was put back in its own bearings. To obtain extreme accuracy in a case of this kind, grind up the bearings of the emery wheel shaft, then fit them closely to their bearings, after which put the wheel in the tool post, fasten the diamond tool to the slide rest as if it were to be ground, and then feed the wheel past the tool. This will do the trick, and the wheel will come out as accurate as it is possible to make it.

If the smith ever has occasion to grind up hardened rolls for a jeweler or some other chap to roll small strips of metal with, never try to grind the rolls on centers. Grind up the roll

bearings on centers, then put the bearings in their own boxes and grind the roll in its own supports.

BUFFING AND POLISHING.

For finishing or polishing irregular surfaces, the smith may with little expense rig up some buffing wheels, which, supplemented with "rag" wheels, will enable him to do almost any job of polishing which is likely to be brought to him. Buffing wheels may be made of well-seasoned white pine or mahogany, thin wood being used and the grain crossed, the layers glued together under pressure, the wheels mounted on mandrels and turned smooth and true. It is best to fit each wheel to its own mandrel, and let it stay thereon all the time.

The best wheels should be faced with leather glued on, the leather turned to a fine surface, then tallow is rubbed into the leather and the wheel rolled on a board sprinkled with the fine polishing material. This type of wheel is ready for use at once after applying the emery.

DANGER OF LATHE GRINDING.

Having very briefly described the methods of lathe grinding and polishing, a word of caution is necessary. There is no work which will so quickly wear out a lathe as tool-post grinding. The reason is that the emery particles torn from the wheel during the grinding operation find their way into the bearings of the lathe, and upon the sliding surfaces, where they imbed themselves and cut the surface. Tool-post grinding, then, should be sparingly done, and as soon as possible rig up separate machines for this work, particularly for polishing and buffing.

CHAPTER VIII.

SCREW CUTTING.

Screw cutting is one of the most interesting operations performed with the lathe. It is second in point of interest only to geometrical turning and is of much more use in practical mechanics. The patterns traced in fine lines on the backs of bank notes and watch cases are formed by a cutting tool held in what is known as the "Geometrical Lathe," or in a "geometrical chuck," which may be used in an ordinary lathe. The screw is formed by moving a cutting tool endwise on a rod a certain distance during the making of a certain number of revolutions of the rod.

Technically a screw is nothing more or less than "a wedge wrapped around a cylinder," as may be easily proven by cutting a triangular bit of paper and rolling same around a pencil, keeping one edge square with the pencil while the other edge of the paper winds on it exact imitation of a screw. In fact, it is a screw. No man or machine has yet succeeded in making a perfect screw. All the micrometers and instruments of precision are made imperfect by the impossibility of making a screw absolutely perfect. Screws are made *almost* perfect, but never quite. The error in a good screw is very slight and the smith will never be troubled by it in any work he will do. In many cases of precision measurements a screw is wanted which shall be of an exact number of threads per inch and which shall be even from one end to the other. It is not yet possible to fill either of these conditions. A screw has never been made with an exact number of threads to the inch, and a long screw made with the utmost care and highest skill known will prove irregular. Some portions will be found "fast" while other portions are "slow." That is: The nut will get ahead or lag behind what should be its proper movement, making a table of corrections necessary for every inch of the screw used in high grade work.

SPINDLE, STUD AND LEAD SCREW.

In front of the lathe, as described in Chapter I, will be found a rod with a key-way cut along that portion of its length over

which the slide rest passes. With the use of this rod screw cutting has nothing to do. Near the rod is a long screw which also passes through that portion of the slide rest which hangs down in front of the lathe and is known as the "apron." The gearing contained in this apron should never be neglected. The smith should investigate it and know how it is arranged, then he should oil it regularly, keep all parts clean and see that no screws get loose to let lost motion get between any of the parts. To do good lathe work the machine must be kept clean, oiled and tight. If you can't do that sell the lathe and buy a shovel instead.

The screw is connected and disconnected to the apron by means of a split nut, which in turn is operated by a lever projecting through the apron. To cut a screw the rod feed is disconnected and the nut clamped upon the lead screw, as it is usually called. The lead screw must be connected with the spindle by means of gears, and upon the number of teeth in the gears depends the pitch of the thread which will be cut by the lathe as set up. For instance, if gears of equal teeth be placed on both spindle and screw then the screw cut in the lathe will have the same number of threads per inch as the lead screw. If a gear having twice the number of teeth be placed on the spindle, the same gear remaining on the screw, then the lathe will cut a screw with only half as many threads to the inch as the lead screw. If the position of the gears be reversed and the larger gear placed on the screw, then the lathe will cut a screw with twice the number of threads per inch as there are on the lead screw.

It is then necessary to properly proportion the number of teeth of the gears connecting screw and spindle in proportion to the pitch of the lead screw and the pitch of the thread to be cut. If the lead screw is, or has, six threads to the inch and it is desired to cut a screw with twelve threads to the inch, then it is only necessary to put a gear of twelve teeth on the screw and one of six teeth on the spindle; then the latter will make twice as many revolutions as the former and the threads per inch will be doubled. Therefore, in "calculating change gears," as the machinists call it, it is only necessary to put on the spindle a gear with a number of teeth equal to the pitch of the screw and on the screw a gear with a number of teeth equal to the number of threads to be cut. This makes a nice easy rule to work by and to remember and

makes the smith independent of the table of change gears which comes with the lathe and which is sometimes fastened to it on a brass plate.

On the head end of some lathes is a swinging arm or bracket which has a projecting stud for the reception of one of the change gears. This part is known simply as the "stud," and a gear is placed upon it simply to make the lathe carriage travel in the right direction. If a lathe cuts a right-hand screw with the stud in use it will cut a left-hand thread with the stud gear removed. The gear on the stud is also frequently necessary to connect the gears on screw and spindle. In this case a second stud would be needed to cut a thread of opposite hand.

SIMPLE AND COMPOUND CHANGE GEARS.

The diagrams herewith presented give an idea of the use of one or more studs. Fig. 29 shows the lathe arranged for cutting

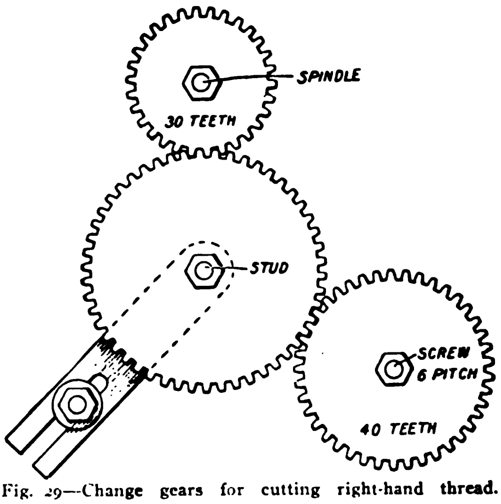


Fig. 29—Change gears for cutting right-hand thread.

eight threads per inch, the arrangement being for right-hand threads, while Fig. 30 shows the arrangement for left-hand cutting. The gear on the spindle has thirty teeth; the No. 6 screw has a forty-tooth gear on it. To cut eight threads requires gears in the ratio of six to eight, and as there cannot be gears of so few teeth we use gears having multiples of those numbers. As regards teeth, we chance upon a factor of five and see how it works

out, as follows: Five times six are thirty teeth for the spindle, and five times eight are forty for the screw. As gears having the number of teeth thus called for are to be found they may be put in place as shown. Or, we may use 36 and 48 gears, or 35

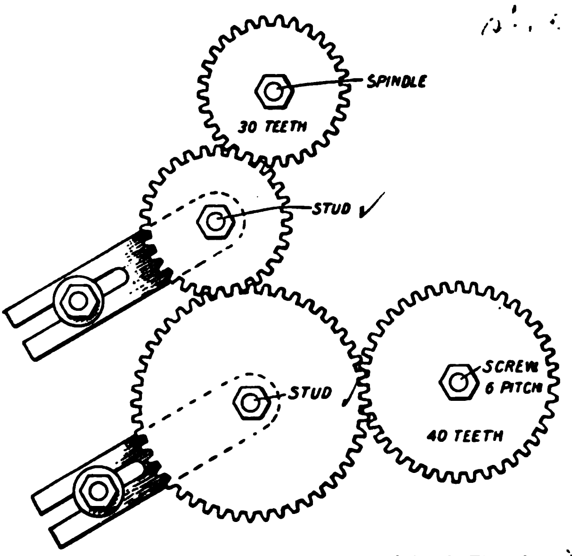


Fig. 30—Change Gears for Cutting Left-hand Threads.

and 56, or any multiple in number of teeth to the six and eight called for by the screw and the thread to be cut.

Having placed the gears as noted above, it will be found that they are not large enough to mesh with each other, therefore it is impossible to drive the lead screw with the gears selected. To connect the gears it is necessary to use a third gear which can be adjusted to mesh with the two described above. This gear is shown on the stud, which is fastened to the lathe headstock by means of a single bolt put through a slot in the foot of stud, thus making an arrangement whereby the stud gear can be pushed into any desired position in order to connect the two gears.

When adjusting the stud take care that the gears do not go too deeply in the mesh, or they will bind against each other. The stud should be so adjusted that the gears all run easily and smoothly. It makes no difference what gear is used on the stud, as it does not enter in any way into the calculation for the pitch

of thread to be cut. If a left-hand thread is to be cut it may be necessary to use two studs, as shown in Fig. 30, although when there is a reverse in the lathe headstock the double stud business is unnecessary, as the reversing can be done by means of the reverse in question without the intervention of the second stud.

Some lathes are fitted with compound gearing for screw cutting. This means that the stud carries two gears which, when applied to a lathe, make the stud gear a factor in the screw

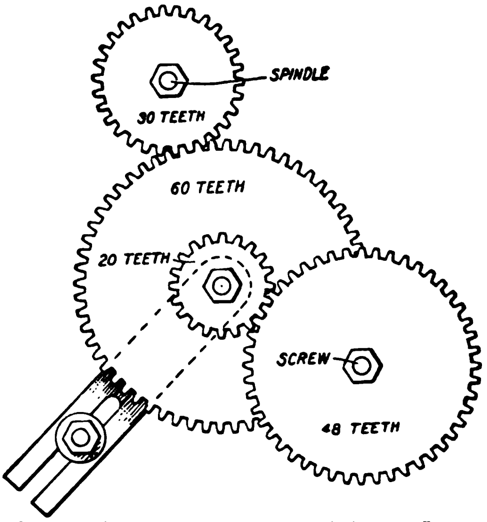


Fig. 31—Arrangement of Compound Change Gears.

cutting, something which is not the case when the gears are not compounded upon the stud. Fig. 31 shows the manner in which compound gears are arranged. In this the stud carries two gears which are securely fastened together, and the number of threads per inch which any pair of gears will cut must be multiplied or divided by the ratio of the stud gears to each other.

"BOX" CHANGE GEARS.

The lathes noted above have each a complete set of change gears permanently mounted on two shafts, something as shown by Fig. 32, in which the upper shaft is the spindle of the lathe, while the lower one represents the lead screw of the lathe. In practice the gears are mounted on short shafts of their own and connected by gears with the parts above mentioned, but the diagram represents the principle of the operation.

A feather with a lump on it, shown at A, is made to slide easily through all the gears, the lumps only engaging one at a time, when the keyway in each happens to coincide with the keyway in the shaft. The feather is moved along in its seat by

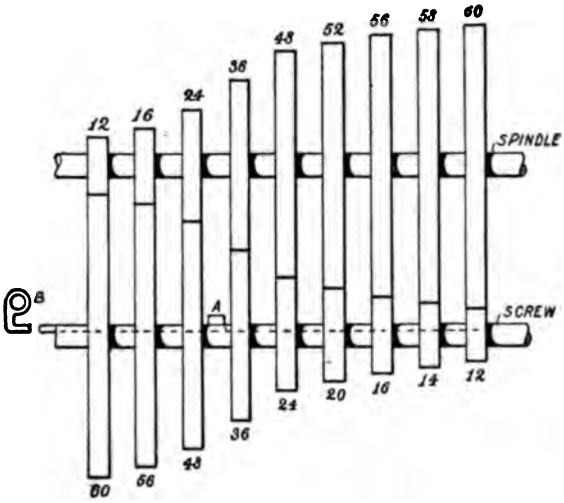


Fig. 32—Modern Gear Box Arrangement.

means of the handle B. When it is desired to use the gears 36 and 36 to cut a thread of No. 6 pitch, same as the lead screw, then the lump on the feather is pushed into the 36-toothed gear shown adjacent to it and the lathe is all ready, as far as the gears are concerned, to cut the thread wanted. It is understood that all the gears on the spindle are permanently fixed to that shaft by means of a feather or by other means. Thus, if it is desired to use gears 12 and 60 to cut a No. 30 thread, then the knob A would be pushed into gear 12 and the lathe is ready. If a thread of 1 1-6 pitch is wanted (which probably never will be called for), the knob A is drawn into the 60 gear and the thread cutting operation proceeds. The gears given in Fig. 32 are purely imaginary and are not as actually used on any lathe. The threads cut by gears of the teeth given would not be very practical, but the diagram serves the purpose of illustrating the principle of the box change gears, for which purpose alone the gears in question are intended.

There are several kinds of threads in use in the United States, and it stands the smith to become acquainted with the standard threads and to work according to the same whenever possible. The United States Standard thread should always be

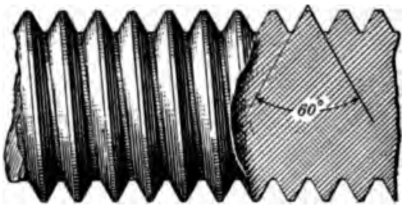


Fig. 33—U. S. Standard Thread.

used on new work unless a square thread is necessary. Two or three other threads are used to a considerable extent, and they are given, in order that the smith may know how to shape them when they are called for. The Standard V thread is often used in the machine shop and it is formed by a simple V-shaped tool

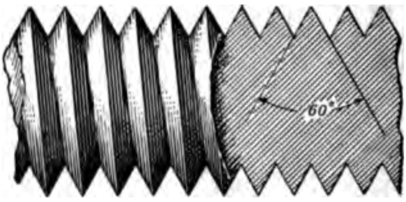


Fig. 34—Standard V Thread.

as described in Chapter V. As shown by the accompanying diagram, the tool must be ground to an angle of 60 degrees and the gauge used for shaping the lathe center will answer admirably for testing the shape of a thread tool, both for Standard V and for United States Standard.

STANDARD THREADS.

The United States Standard thread differs from the Standard V thread only in having the top and the bottom of the threads cut off. Both these threads have an angle of 60 degrees. The Standard V threads has a depth of 0.85 of the pitch. The United States Standard thread has a depth of only 0.65 of the pitch, and as one machinist aptly expressed the matter: "A roughing tool for a V thread will just cut a Standard United States thread." It is one of the beauties of this thread that the tool stands up

well under the cut—much better than when cutting the V thread, where the wearing off of the point of the tool is the one great grievance the machinist has to overcome—and he could get around the difficulty only by grinding off the point of the tool so it would cut a flat top and bottom thread—United States Standard in fact—then he would later sharpen up the tool and cut out the bottom of the thread, thus making it into a Standard V thread.

The Whitworth thread originated in England. It is practically the United States Standard thread with the top and bottom

Fig. 35—Whitworth Thread.

of the thread rounded. The angle of this thread is 55 degrees, 27½ degrees on either side of a vertical line drawn through the thread. The depth is 0.75 the pitch, and the thread is, as stated, rounded top and bottom. The tool is quite a hard one to grind and the thread possesses little if any advantage over the United States Standard thread.

Fig. 36—The Square Thread.

The Square thread is made both single and double, and is used for heavy work, like presses and similar machinery. The angle is square and the depth equals half the pitch plus 0.01″ to 0.03″ clearance. The width between threads equals half the pitch plus clearance. When cut double it is a quick-acting thread. An ordinary cutting-off tool with a good deal of side clearance may be used for cutting this thread.

The Powell thread is much like the Square thread, with certain characteristics of the Standard United States thread. It is used for the same purposes as the square thread, and may be

Fig. 37—The Powell Thread.

cut with the same tool by merely grinding off the corners of the tool to the proper angle. The depth of this thread equals half pitch plus clearance. The width of thread at top is 0.37 of the pitch and the space at the bottom is also 0.37 of the pitch.

TAKING ROUGHING AND FINISHING CUTS.

Having set up the change gears and made a tool in accordance with the direction given above and in previous chapters, start the lathe and run forward the tool until its point barely touches the work. Stop the lathe without moving the tool and apply to the slide rest carriage a sort of clamp which will be found among the furnishings of the lathe. The clamp has a set-screw by means of which the carriage or the cross-feed may be permitted to advance more or less by slacking off on the set-screw with the fingers. Bring the screw to bear, clamp the casting, and see that the point of the tool barely touches the work, which, by the way, must be so held that it has no lost motion back or forth. Tie or wedge the dog in such a manner that the work cannot move forward or back without the lathe-spindle going with it.

There are three ways of starting a thread. Either the cutting may get into the metal on a gradual slant or taper, or a hole may be drilled in the work at either end of the thread, or a portion of the work may be turned down at either end of the proposed thread to a diameter equal to that of the bottom of the thread, as found from the description of each thread given above. This is the most satisfactory way and should be employed whenever possible. The turned down portion of the work where a thread stops is technically known as a "run-off."

Start the lathe and run the tool the entire length of the thread blank, setting the tool forward until it takes a slight cut, then bring the set-screw against the cross-feed so the tool can go no deeper. Arrived at the end of the cut, screw the tool back clear of the work. If a run-off is used there is time enough for this, but if a drilled hole stops the thread it will be necessary to stop the lathe before the hole is reached and to turn the lathe by hand by means of the belt a few inches until the tool enters the drilled hole, when the tool is to be moved back as above described.

When the thread tapers into and out of the work it is necessary to run the cross-feed back by hand at the instant when the tool reaches the end of the cut. This requires nice judgment on the part of the latheman, and the beginner should practice with a generous run-off at either end of the screw until he "gets the hang" of the new school-house. Having arrived at the end of the thread, with the tool run back, reverse the lathe and let the lead screw run the carriage back to the beginning of the thread. While this is being done screw back the little set-screw just the depth of another cut with the tool. A little experience will quickly tell how much, and a few broken tools or screws twisted from between the lathe centers will indicate the proficiency of the learner.

"CATCHING THREADS VS. RUNNING THE CARRIAGE BACK."

It requires a very considerable length of time for the lathe carriage to be screwed back after each cut, and the lathesman will soon cast about for means of saving some of the time thus lost. As he becomes expert with the lathe he will find that in cutting some threads the nut may be opened by unclamping, the lathe carriage run quickly back by hand in a fraction of the time required by the screw and the nut clamped in again, picking up or "catching" the thread exactly as if the lathe had been run back by hand. This is true when the thread being cut is the same in pitch as the lead screw. It is also true with some multiple pitches of that screw, but there are certain threads which cannot be caught up without some special maneuvering. For instance, to cut a No. 7 thread and catch the screw just right each time would require considerable study and take longer than to run the carriage back by reversing the lathe.

A quick and sure way of catching any thread is as follows: Make a mark on the large pulley or on the flange between that pulley and the gear on spindle. Bring the mark to coincide with another mark on the lathe head, and at the same time rig a stop which will prevent the carriage from being moved any farther toward the headstock It is evident that with the spindle and carriage in this position the nut can always be locked in the same place, therefore cut to the end of the screw, unlock the nut, run carriage back by hand to the stop, stop the lathe on the two marks, throw in the nut and go ahead with another cut on the thread.

CHAPTER IX.

INTERNAL TURNING OR BORING.

A general idea of the form of tool for boring was given in Chapter V and the simple tools therefor were illustrated. Boring, in the accepted meaning among machinists, means cutting metal off the inside of a cylinder, while "turning" means the cutting of metal off the outside of the cylindrical shape or body. But in actual work boring is very seldom done with a tool shaped like any of those illustrated in Chapter V. It is only in job work, where a single hole is to be made, that boring with a lathe tool is resorted to. And even then the lathe tool is used if no other tool can be found with which to do the work.

But as the smith proposes to do little else except job work it is in order to tell how to do a good job of boring with ordinary lathe tools. To begin with, always use as large a tool as can be gotten into the hole to be bored. Never make use of a slim tool when a heavy one can be used as well as not. Above all things, never, under any circumstances, forge down or alter over a standard tool to do some special job. Have some tools for that purpose alone, and even then, whenever possible, forge up a new tool for the job in hand and then make that tool one of the standard ones, for never yet was a lathe tool made but what it will come in very handy: in fact, be just the thing for some similar work.

The more lathe tools the better. They are a very good investment, and money put into tools of any kind is always money well invested. Don't begrudge the money you spend for tools. In setting a lathe tool in the tool-post always place it in such a manner that when it springs under the strain of a cut it will bear against the side of the tool-post. This matter was fully described and explained in Chapter V also, and inside tools as well as those for outside turning should always be placed against both sides of the tool-post slot, and the tool-post twisted around until the desired position of tool has been reached.

The clearance necessary in a boring tool varies with the

diameter of the hole to be bored. Were the size of the tool used always in proportion to the diameter of the hole to be bored there would be no difference in the angle of clearance necessary, but as the tool selected should, as stated, be as large as can be

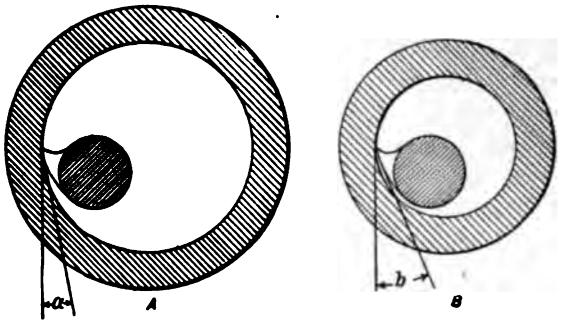


Fig. 38—Clearance of Boring Tools.

used in the hole, the clearance must necessarily vary as shown by Fig. 38, where the tool fills more of the small hole at B than it does of the large hole at A, whereupon the machinist grinds back the lower portion of the tool in order to get it into the hole in the proper position to do good cutting. Should the smith-machinist go to the trouble of making up tools for small holes and other tools for large holes, then he can grind the clearance of each tool on the same angle as shown at a. in sketch A, merely grinding the clearance of the tool on a circle instead of to a straight line as shown by both sketches A and B. But the smith machinist does not like to do this, therefore he grinds more clearance for the tool in the small hole and lets it go at that.

USE OF THE CHUCK AND THE STEADY REST.

As a usual thing it is not possible to do a job of boring with the work suspended between centers. On very large shallow holes this may be possible, but it is not practical one time in a hundred, therefore the tail-center must be dispensed with when boring is to be done, and the work must be held in the lathe in some other manner than between centers. Usually the chuck does duty in this business, and when the work is of considerable length the steady rest must be brought into use also.

Suppose it be necessary to bore out a shaft collar from 1 15-16 to 2 3-16 inches. The first thing is to chuck the collar.

For this purpose, if the lathe has been fitted with a chuck, remove the small face-plate which is used to drive dogs when turning ordinary work, and put in place the chuck, screwing it on the spindle as far as it will go. Some men have the very bad habit of putting on a chuck by starting the spindle, no matter whether the belt happens to be on a fast or on a slow speed—and letting the chuck screw home and fetch up with a jerk at the end of the threaded portion of the spindle. This is bad enough when putting on the little face-plate used for dog driving, but when a heavy plate or a big chuck is thus put in place there is danger of seriously straining the spindle, particularly if the belt happens to be on a fast speed.

A good way to put on a chuck is to hold it in place with the right hand and turn the spindle with the left hand by means of the belt until the chuck has been screwed home. Or a careful man may hold the chuck with one hand and start the lathe on a slow speed with the other hand, making sure to stop just before the chuck goes over the last thread, which should be screwed up by hand. Another abuse of face-plate or chuck, which should be avoided, is to start them off by putting a piece of iron in position for the jaw of the chuck to strike against, and then giving the belt a pull, catching the chuck on the jaw as above, stopping it dead, and letting the momentum of the lathe spindle and its load of pulleys and back gears start the chuck or plate. This is very bad practice and should always be avoided. Start the chuck by means of a lever placed between the jaws of the chuck, or between two bolts placed in slots or holes in the face-plate. Pull on the lever and the plate or chuck will start. If it should chance to be on extra tight, throw in the back-gear and put the belt on the largest pulley. Thus rigged, there will be little difficulty in holding the spindle against the pull of the lever, the teeth of the back-gear are strong enough to stand the pull provided that the step pulley be not locked to the back-gear, which is one of the surest ways of breaking the teeth out of one or both of the gears. Holding the spindle by means of the back-gears and the belt permits the spindle to yield a little when the lever strain comes on, through a slight giving of the belt.

Having put the chuck in place, take a grip on the outside of the collar, making sure that the jaws of the chuck (if an independent chuck be used) are all the same distance from the center,

which is determined by their distance from the outer edge of the chuck, or from any one of the concentric rings with which the face of the chuck is finished. These rings are for the purpose of centering the jaws whenever necessary, and they should always be made use of when putting work into the chuck. Of course if the chuck be a universal one, the centering business can be dispensed with and it is only necessary to put the work in place and screw up the chuck. Even then the work should be tested to see if it be centered truly, for sometimes there are lumps or projections on the surface which prevent the work from centering itself exactly.

When such is found to be the case, it is necessary to pack under one or more of the chuck jaws, using thin metal strips or thick paper, until a bit of chalk held against the work while it is revolving will make a mark entirely around the surface. In chucking the collar above mentioned there were one or two rough places in its surface where a hammer had been used some time or other, and one of these places coming under the jaw of a universal chuck, threw the work out of round a trifle. It was not very much, but enough to spoil the accuracy of the work when a good job was necessary.

By holding a bit of chalk against the surface of the work the high places can be easily detected and the chuck shifted accordingly.

ACCURATE CENTERING.

It is not possible to center as accurately as sometimes is necessary by using the chalk method, hence for extra nice work an "indicator" should be used which will magnify the excentricity of the work. Such an indicator of the "home-made" variety is shown by Fig. 39. It is a very simple device and is easily made. Its principal parts are: A bar or shank, D, which fits into the tool-post the same as a tool would be placed, and the bar is made with a split end, hollowed out as shown by detail E, to receive the ball which is formed upon pointer C at B. The enlargement B is placed in the hollow cavity in bar D, and the two act as a ball and socket joint in permitting free though limited motion of the pointer C, which, when in use, is placed with its lower end against the object to be centered, as shown at A. When this is done the revolution of the work, should there be any inequali-

ties in the surface thereof, causes the short arm to vibrate with the inequalities, and the motion being greatly magnified by the

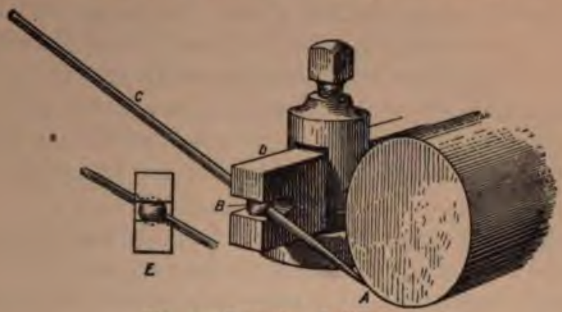


Fig. 39—Centering Indicator.

long arm C, is rendered visible in a marked degree by the vibrations.

The piece to be chucked being put in as close as the eye can determine, the pointer is placed in position and the lathe started on a very slow speed. If the work be the least out of truth, the long arm C will rise and fall with every revolution of the work and the workman has only to note the position of the arm and move one of the jaws of the chuck accordingly. A very little practice with one of these indicators will enable a man to quickly chuck a round piece of material with an accuracy which could never be even approached by the best lathesman in the country working without the indicator.

The indicator may be easily made by any blacksmith and its cost will be but a trifle, while its value is great. The device can be applied to inside as well as outside surfaces. In that case it would be made to work in the top of the hole, while for exterior work it works as shown, against the bottom of the object.

To true up work when an independent chuck is used—and by independent is meant that the three or four jaws of a clutch all work independent of each other, each being controlled by a separate screw which is set up, as required, by means of a wrench which fits all the screws. The universal clutch, on the contrary, has as many screws as it has jaws, of course, but these screws are all connected by means of a large connecting gear so that turning up any one of the screws causes all of them to advance an equal distance.

Some chucks, however, do not have any screws. Instead the

jaws are advanced by a sort of spiral which is placed just inside the face of the chuck and which may be rotated from either one of several places in the chuck. Other universal chucks have a shell which screws over the front end of the chuck and carries with it the jaws which hold the work in place. Both the independent and the universal chucks have their good points, and both should be provided as soon as possible by the smith-machinist who desires to do good work and lots of it at a low price.

The large face-plate may be and should be made into a chuck by means of four movable jaws which may be bolted at will to the face of the chuck, forming a large independent chuck which is very useful in holding pulleys and similar work which will barely swing above the lathe bed. Bear in mind that the jaws of all good chucks should be made to reverse so as to hold a ring or pulley from the inside of the rim as well as from the outside thereof. Many good chucks are designed with this end in view. In selecting chucks pick out one of this kind, also see that it is adjustable for wear and that it is strong and well constructed.

SETTING THE STEADY REST FOR BORING.

Place the work in the chuck as directed above, supporting it entirely by that means, provided the work is not so long as to pull out of the grip of the chuck by its own weight. Having made the far end of the work (the end farthest from the chuck) run as true as possible, proceed to put the steady rest in position as close to the end of the work as possible, and make sure that the bearers of the rest lie fair against the work before they are tightened into place.

The surface of the work must be clean and smooth where the steady rest is to bear, otherwise good work is impossible under any condition. It is not possible to true up work in the steady rest by means of the center indicator, for this tool will not work unless the work be held in the lathe entirely by the spindle and its attachments (face-plates, chuck, etc.). Keep the bearers of the steady rest well oiled at all times when the lathe is running. The least stick, chatter or jumping between the work and the steady rest and good-bye to the possibility of decent work.

When an object too long to be first supported and trued up

by and from the face-plate or chuck has to be bored, then it is time to rig up some other means of holding the work in the lathe. Bear in mind that a boring tool must project from the tool-post, a distance greater than the length or depth of the hole to be bored, and it will be seen that the limit in boring with an internal lathe tool is reached very quickly. Not over eight or ten inches overhang should be permitted in any lathe a smith is likely to have in his shop.

When a greater depth than 10 inches must be bored, the process becomes what is known as "cylinder boring" and the work is made fast to the slide rest of the lathe and is moved forward against the tool by the same feed which moves the tool in ordinary outside turning. For this work a special tool is required which is known as a "boring bar."

THE BORING BAR AND ITS USE.

A boring bar, as usually made, consists of a piece of heavy shafting the length of which is two and one-half times that of the hole to be bored. Fig. 40 gives a general idea of a boring bar of this kind. Its diameter is 1 15-16 inches, and the length about three feet. A hole over 22 inches can be bored with this tool, provided it is large enough to allow a portion of the tail spindle to enter, in which case that portion of the spindle which

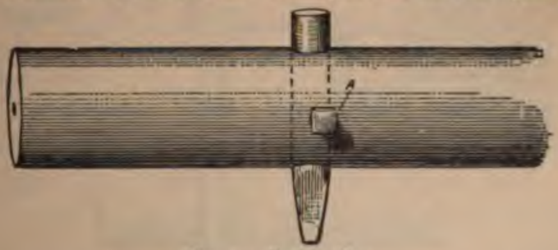


Fig. 40—Boring Bar.

enters the hole can be considered as a part of the length of the boring bar, and must be so considered when figuring the length of bar necessary to bore a hole of given depth.

The tool is simply a piece of round tool steel, ground to the required shape and tempered. It is held in place by means of a set screw which is shown at A. The bar is placed between the lathe centers and is rotated by means of a dog in exactly the same manner as if it were put in the lathe to be turned. In

fact, the entire operation is exactly the reverse of turning, for the tool is placed between centers while the work is fastened to the slide rest.

Still another form of boring tool is shown by Fig. 41. This is technically known as a "chucking tool" and really belongs more to the drill and reamer tribe than to the boring family. As shown by the engraving, this tool is a good deal like the one presented by Fig. 40, save that the cutter is close to one end instead of being in the middle, and usually fastened by a screw in the end of the bar. Fig. 41 gives a pretty good idea of this tool, and the method of using it.

THE "CHUCKING" DRILL BORING BAR.

The lathe chuck or face plate is represented by A, and the cylinder to be bored is shown at B, while C is the boring bar, D the cutter and E is a wrench to prevent the boring bar from turning around. A rest to support the wrench is shown at E, while G represents the tail spindle of the lathe. To operate the

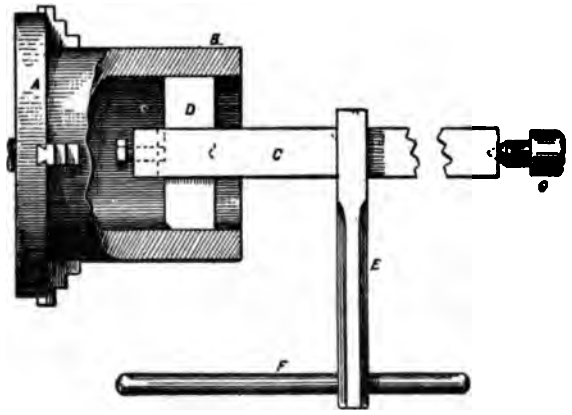


Fig. 41—"Chuck Drill" Rigging.

device, the work is first chucked in the ordinary manner and supported by the steady rest, if necessary. The tool is placed central in the bar and screwed fast, then the wrench is slipped on the bar, which is placed against the tail spindle of the lathe which enters a center made to receive it. The wrench E, may either be a bit of flat iron bent up to fit the square of the bar, or made with a square hole worked through it, is to prevent the

bar C from revolving with the work. The wrench bears upon the rest F, which may either be the ordinary wrench of the drill lathe or it may be a piece of iron placed in the tool-post and turned lengthwise of the lathe. In many instances the wrench is made to be held directly in the tool-post, in which case it stands at right angles to the lathe bed.

As shown by the engraving above referred to, and more plainly by the detail, Fig. 37, the leading end of the cutter is beveled off a little and this bevel will become greater as the tool is ground time after time. The center which receives a projection in the end of the boring bar is plainly shown at A and C, Fig. 42, while B shows how the clearance is provided for. To make these cutters they are usually turned in the lathe in order to make the center come true, after which they are ground or filed off to give the necessary clearance.

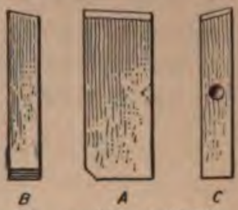


Fig. 42—"Chuck Drill" Cutter.

This tool, once started in a cut, will go straight through the work with very little variation from the direction in which the bar is pointed. A straight and very true hole can be depended upon when this tool is used, provided the tool is kept in good order and ground evenly when the least bit dull. These tools, for holes up to 4 inches in diameter, are usually made of steel ½ x 1 inch for the larger sizes, and ⅜ x 1 inch for the smaller sizes. The bar C, Fig. 41, is usually made of 1-inch square steel.

PROPER SETTING OF BORING TOOLS.

The proper setting of the tool above shown needs no care, as it is automatic in that direction and centers itself. It does, however, point to the proper way of setting all internal tools, that is, to have them exactly radial to the center line of the object to be acted upon.

CUTTING INTERNAL THREADS.

In internal threading the operations are the same as when boring with the overhanging tool, but modified by the practice of external threading. In fact, internal thread cutting is a modification of the two operations above noted. There is one necessary requirement which must never be overlooked, and that is: the making of a generous "run-off" at the bottom end of the proposed

thread into which cavity the tool can pass when it reaches the end of its travel. No good internal thread can be cut in the lathe without first making the run-off mentioned.

REAMING IN THE LATHE.

It is frequently necessary or desirable to ream holes which have been bored or drilled. To do this, either use one of the cutters shown by Fig. 42 or use a fluted reamer, placing the squared end against the tail center, and holding the reamer with a wrench fitted to the squared shank. The great danger in reaming in the lathe is in the tendency of the reamer to become clogged as it lies down and the cuttings cannot drop out as they do when reaming vertically. However, with a little care in feeding up the reamer, and with frequent stoppings to clean out the cuttings, excellent results can be obtained by reaming in the lathe as described.

CHAPTER X.

THE FACE-PLATE.

The face-plate of a lathe has two principal uses: First, for imparting motion from lathe spindle to whatever work may be between the lathe centers. That is one office of the face-plate. The other use is for supporting work which is large in diameter and usually of little length. For the two purposes above noted, two face-plates are usually sent out with a lathe—sometimes three—a small plate with a slot for the tail of a dog, a large plate as big as can be swung over the ways of the lathe and a driving face-plate. These articles are usually about as shown by Figs. 43, 44, 45, 46. The small face-plate, Fig. 43, has a slot cut in one side from the edge clear down to the hub. This slot is for the tail of the dog which is to drive the work when between-centers jobs are being done. The small four-arm face-plate, Fig. 44, is for the same purpose with the additional use of permitting small work to be bolted on with two or four bolts. This is a very handy feature when some jobs have to be done and it saves drilling holes in a solid face-plate to accommodate the special work.

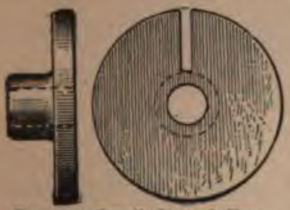


Fig. 43—Small Slotted Face-Plate.

For large work, the big face-plate, Fig. 45, is indispensable. All sorts of jobs may be clamped upon it by the use of some bolts and a few pieces of flat iron, as will be described later in this chapter. This face-plate is made as large as will swing in the lathe and great care should be taken that it does not get abused by tool marks, chisel cuts or other careless earmarks of shiftlessness. Great care should be taken when putting the large face-plate on the spindle, that the latter is not bent by careless screwing on of the heavy face-plate. As stated in a previous chapter, great care should be taken in screwing a

Fig. 44—Driving Face-Plate.

heavy chuck in place, for, if belt power be used to screw on the chuck or face-plate, it will usually bring up in place with a jerk, which, if it does not spring the spindle, will certainly cause the chuck to stick so tight on the spindle that it is very hard work to get the chuck off again. Furthermore, screwing the plate upon the

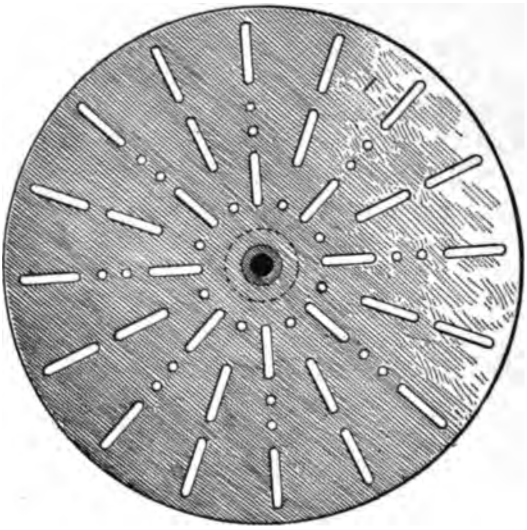


Fig. 45—Large Face-Plate.

spindle excessively tight is very likely to cause the plate to wobble or otherwise run untrue. It is always best to pull on the belt with the hand, when a large face-plate or chuck is being screwed home, and just barely bring the plate hub against the shoulder of the spindle. A plate put on every time in this manner will always run true and the spindle of the lathe will stay in fine condition a long time.

The "smith-machinist" will do well to get up a pattern and make up several small face-plates like Fig. 43. These plates are very handy things to have, and they may be made into special chucks for some kinds of work which the smith finds will come along frequently. A pattern of the large plate is also desirable, for a very handy independent chuck can be made up on one of the large plates, which once rigged should be kept for a chuck and not used for anything else.

When putting on a face-plate or a chuck, certain things should always be done, among which are: Be sure to remove

the center from the spindle whenever any job is to be done which does not require the center for the support of the work; also when drilling is to be done by means of a drill attached to the tool-post or to the tail stock, be sure to remove the center from the spindle. This center is technically known as the "live" center to distinguish it from the center in the tail spindle which is known as the "dead" center. As soon as the center is removed stuff a wad of waste into the taper hole and let that waste stay there until the center is to be put in again. This keeps all the metal chips out of the hole and makes easy the replacing of the center, for it is only necessary to pull out the waste and the hole is bound to be clean and all ready for the insertion of the center.

The spindle is hollow, so always keep a rod handy for poking out centers, drills, etc. Forge a head 2 inches in diameter on one end of the rod and let the rod lie in the spindle unless its rattle when the lathe is running proves to be disturbing. With the rod in question the wad of waste can be pushed out and the spindle is all ready for the center, without any time being spent digging out dirt or scale or lathe chips.

"CHUCKING" WORK IN THE LATHE.

The machinist has some queer technical terms which he uses in his business and the smith has a few of his own which are as strange to the machinist as machinist terms are to the smith. For instance, everything which is put into the lathe to be operated upon is known as "work," and if the object is bolted to the face-plate it is said to be "chucked." When a hole in the "work" is to be cut out larger by means of a tool in the tool-post the operation is called "boring." If a hole is drilled to any given diameter, and the machinist passes another drill a size larger through the hole, the second operation is not "drilling," instead, it is technically known as "reaming," for the larger drill merely reams a little off the walls of the hole already made.

Suppose that in the course of work with the lathe it becomes necessary to fit up some new shafting and pulleys, and that a certain pulley could be used provided it had a little larger bore. The sizes of shafting run 1-16 inch less than even inches and half inches, for instance, 15-16 inch, 1 7-16 inch, 1 15-16 inch, 2 7-16 inch, 2 15-16 inch, etc. The reason for this strange size is that when square shafting was abandoned only forty years ago, and

round shafting came into use, every machine shop had to make its own shafting, so they bought 1½-inch, 2-inch, 2½-inch iron, etc., and turned their own shafting. It required 1-16 inch of metal for the finishing process, hence the odd sizes of shafting which remain in use to-day and which are here to stay.

But suppose that a 22 x 8 x 1 7-16 inch pulley needed to have the hole in the hub increased to 1 15-16 inch. The first operation will be, as the machinist expresses it, to "get it in the lathe." The machinist never "puts" a thing in the lathe; he "gets" it there. And about that pulley: in describing any pulley, always state the diameter first, then give the width of face, next the diameter of bore of hub, then state whether the face is flat or crowned; lastly, tell whether the pulley is set-screwed or key-seated, or both. In making a schedule of pulleys it will run something as follows:

1 pulley 22 x 8 x 1 7-16 inches C. K. S. (crowned face, key-seated).

1 pulley 22 x 8 x 1 7-16 F. S. S. (flat face, set-screwed).

1 pulley 22 x 8 x 1 7-16 inches C. K. S. S. & K. (crown face, key seat and set-screwed and key).

2 pulleys 22 x 8 x 1 7-16 inches C. S. S. T. & L. (crowned, set-screwed, tight and loose).

In this description the statement that the pulleys are crowned face is entirely unnecessary, for the reason that tight and loose pulleys for a shifting belt are invariably made crowned face. Two ordinary pulleys will not answer for tight and loose pulleys, as the hub of the loose pulley must be in length equal to the width of face of pulley at least, and as much longer as possible, depending upon the diameter of shaft. In all cases the length of a loose pulley hub should be four times the diameter of the shaft. The above description, while not relating strictly to the lathe and its use, is something which the machinist-smith should know, and as the best time to learn new things is the present time and minute, therefore the facts are stated at this time, somewhat out of their logical precedence.

CHUCKING A PULLEY.

The object in "chucking" a pulley is to fasten it to the face-plate of the lathe in such position that the rim of the pulley will

run perfectly true, which means that each and every portion of the pulley face is the same distance from the center of the pulley. If there is at hand a short piece of shaft with a center at each end thereof the chucking problem is an easy one and all that is necessary is to put the bit of shaft between centers with the pulley shaft upon it. Then slide the pulley up to the face-plate and clamp the pully thereto by means of several bolts. Fig. 46 will give an idea of the way to bolt the pulley.

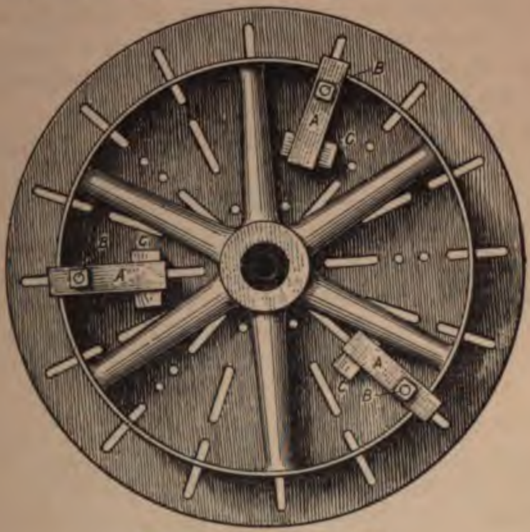


Fig. 46—Chucking a Pulley.

Three or four bolts may be used (the illustration shows three), each long enough to go through the face-plate with a nut and washer on the back thereof, and to project about one inch in front of the pulley. The bolts, B, B, B, are passed through the iron straps, A, A, A, which may be 2 inches wide, ¾ inch thick, and 6 to 8 inches long, with a hole drilled through large enough to easily pass one of the bolts. At C, C, C are shown pieces of material in length equal to the width of the pulley face. Hard-wood will answer very well, or short pieces of bar iron may be used. Every lathe should have a number of such pieces, sawed off square, and a certain number, say four of each, cut to the same length. A set may be made 4 inches long, another set 5 inches long, another 6 inches, and so on, as required. One-inch square iron of fair quality is cheap, and lengths may be cut off as needed

until a full graduated series of lengths has been provided. If you have a set of 8-inch bars, and require some 7-inch, do not cut off the 8-inch ones. Instead, just cut off another complete set of the required length and put them in the tool rack when done with them. They will come in handy, time after time. The first use pays for them, the next and succeeding uses is clear profit.

When a very heavy pulley is to be chucked considerable more holding power may be obtained from the bolts by making the holes in the clamp-bars, A, Fig. 46, in such a manner that the bolts come close to the pulley rim. About double the holding power is obtained from the bolts by so doing.

After the pulley is clamped fast as described above, push back the tail-stock and remove the short piece of shaft from the pulley. Also remove the head center, plug the hole with a wad of waste, and go ahead with the boring-out process. When there is no piece of shaft available, place the pulley as near central as possible, then proceed to center it as directed in Chapter IV, using the chalk or the center indicator, if one is at hand.

CHUCKS VS. FACE-PLATES.

A large chuck is a fine thing for the smith to have in his little machine shop, but chucks are very expensive things and not one smith in one hundred will feel able to put up $200 or so for a large chuck. Such being the case, an excellent substitute for a large chuck may be made by the smith for one-tenth the sum named. Procure or make another large casting for a face-plate, similar to that shown by Fig. 45, except that there shall be no slots made or cast in it. The face of the plate shall be turned smooth and true, then drill rows of holes, as shown by Fig. 47, also draw circle within circle on the face until the entire surface is covered with circles one-half inch apart.

The circles are very handy when chucking anything that may have to be put into the lathe, as the face of the object need only be brought to one of the circles, or equally distant all around from one of the circles, to be approximately centered; quite near enough to begin on with the chalk or indicator.

To make the very handy chuck shown by the preceding figure it is only necessary, in addition to the face-plate, to make up four bolts and screws, as shown by Fig. 47. For a 24-inch

face-plate the head of the bolt may be 1½ inches square and the bolt should be about 1 inch in diameter, or to fit the holes in the face-plate. The screws should be about 3 inches long, ¾ inch in diameter, and the threads should be removed for at least ½

Fig. 47—Large Independent Chuck.

inch at the point to prevent upsetting of the screw in such a manner that it cannot readily be backed out of its nut. Sometimes a very fine adjustment is needed, and to obtain it a check-nut may be placed on each square nut next to the point of the screw. By setting up the check-nut a little slack may be taken out of the thread in the nut and a much finer adjustment given to the work than is possible with the plain screws alone. The check-nut shown may be omitted if there is no room for it, or, if used for locking only, it may be placed between the nut and the head of the screw.

It is usual when using a face-plate chuck of this kind, and it is well with any other chuck, to reinforce the holding power of the adjusting screws (Fig. 47) by two or three bolts and clamps to hold the work against the face-plate and to furnish the necessary driving power, thereby relieving the adjusting screws of that work, making it necessary for them to hold the side adjustment of the work only.

The chuck bolts shown may be used either outside or inside the work as desired, by simply reversing them and pointing the screws in the other direction. By thus arranging the bolts a pulley fully as large as the face-plate may be chucked with perfect ease, the adjusting screws bearing outward from the inside of the pulley-rim, instead of inward, as shown by Fig. 47. For holding irregular work in the lathe these bolts leave nothing to be desired, and by means of these adjusters and the clamp bolts it is a mighty obstinate bit of work which cannot be held to the face-plate of a lathe.

CHUCKING WITH WOODEN SHAPES.

When very peculiar shapes require chucking, particularly where there is no flat surface to work from, it is sometimes necessary to use a piece of wood between the work and the face-plate. Proceed to select a bit of wood—soft wood if only one or two pieces alike are to be chucked and hardwood if a considerable number of pieces of work are to be operated upon—then proceed to cut out such portions of the wood as will let the shapes lie upon the face-plate in the position in which it is required to bore the hole. When the wood has been fitted place the work in place and hold by bolting, or by the use of clips in the way already described. There is no end to the way in which odd-shaped pieces of metal may be fastened and placed in position for working in the lathe. A little ingenuity is all that is required by the smith to handle any case of this kind which may come along.

Sometimes, for very obstinate cases, calcined plaster is used for holding the work in place. In this case the plaster (ordinary plaster of paris) is mixed pretty thin with water and, after the metal has been blocked, propped or wedged in position, the plaster is poured over (and under) the work, giving it a perfect bearing upon the face-plate. This is an excellent way to support thin metal plates when work is to be done on them in the lathe. The plaster will hold them without a tremor when the tool comes along.

When it is desirable to hold very small pieces of metal in the lathe and to fasten them firmly and quickly, also to be able to just as quickly remove the pieces from the lathe, a face-plate covering with sealing wax will do the business. Coat the wax

over the plate as needed, letting it get from 1/8 to 1/2 inch deep as necessary, keeping the plate warm by means of a hot iron, a lamp or some other arrangement, then press the piece to be chucked right into the wax until it is in the position desired as regards being central, etc.

A most excellent way of centering small pieces which are to be held as above is to heat the wax just hot enough to stick firmly to face-plate and to the work, and yet allow the latter to be moved slowly in any direction. Then, while the wax is in the condition above noted, press the work one way or another until it is centered as desired. If it be a small finished flange, which it was not thought best to run the risk of scratching or springing in a chuck, and there was a hub or other projection, just stick it on the wax, then run the slide-rest up to the work, clamp the tool-post, and with a stick or a smooth tool hold the work in the desired position while the wax cools, the lathe revolving all the time while the wax is cooling.

The above-described method of chucking is frequently used by watch repairers for holding in the lathe small wheels or gears with the pinions and shafts all in place. The method is just as useful to the machinist as to the watchmaker, and there is no limit to the size of objects which may be chucked in the manner described. To remove the work heat the wax and the metal will readily separate from it. Frequently a smart tap with a hammer will free the entire object from the wax. If some of the wax adheres to the metal a little gasoline and a brush will quickly clean the metal surface.

CHAPTER XI.

BORING IN THE LATHE.

A short description of the boring bar and its use was given in Chapter IX, and a simple form of boring bar was shown by Fig. 40. Several sizes and lengths of this useful tool should be made up by the smith-machinist and will be found very useful and paying investments. The bar shown by Fig. 40 requires a hammer adjustment when the cutting tool has to be set out to a greater diameter. For most kinds of work this form of adjustment will answer every purpose, but when dealing with very large bars a better form of tool adjustment is necessary, in which case a collar may be placed over the tool as shown by Fig. 48 and the tool forced out at will by means of the set-screw shown in the engraving in question.

An ordinary collar is used, the usual set-screw being replaced by one long enough to reach through the shaft as far as the cutting tool. It is well to make the collar at the same time the shaft is made so that the hole for the tool may be drilled with the collar in place. Drill the tool hole through one side of the collar and completely through the boring bar, but not through the remaining side of the collar. Instead, finish this hole with a "tapping drill"—that is, a drill which is just large enough to receive the tap for a set-screw of the required size. If an ordinary

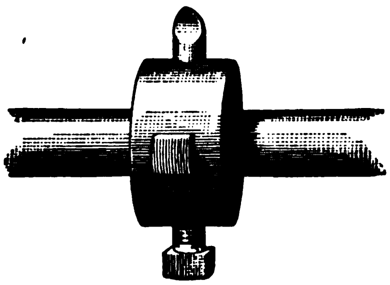


Fig. 48 —Boring Bar Tool Adjustment.

finished collar is used the holes above mentioned may be drilled at right angles to the regular set-screw hole, but if the collar be made after the boring bar has been finished, a little figuring must be done to get the tool hole in collar exactly in line with the tool hole in the boring bar.

An ordinary cast iron collar may be used as described above, but it makes a pretty brittle member and it is much better to forge a good steel collar and bore, turn and drill it to fit the particular boring bar it is intended for. These adjusting collars can only be used on holes of considerable size where there is room enough to admit the boring bar and collar also, but for making large holes these collars will be found most excellent, not only for tool adjustment to a nicety, but for supporting the tool as well. The collar provides a bearing for the tool much closer to the cutting edge than is possible without the collar.

BORING SMALL CYLINDERS.

The smith-machinist will frequently be called upon to repair small cylinders for steam engines, pumps and possibly for automobiles, but beware of the latter work unless it is done by the hour, and under no circumstances assume the risk of making certain automobile repairs for a lump sum. At present automobiling is a luxury, therefore let repairs to those machines be a luxury also, for those who own autos are, or should be, abundantly able to pay well for repairs.

Certain engines in use for small power units have their valves made in the form of pistons, operating in cylinders of less diameter than the cylinder of the engine. Whenever valves of this type become leaky, about the only remedy is to bore out the valve cylinder to a diameter which will remove all the large places and leave a true cylinder in place of the locally worn mechanism. The same is true with certain pump cylinders, both power and hand pumps, some types of which have a small, short iron cylinder in which the lifting valve moves.

MOUNTING THE CYLINDER.

A cylinder of this kind, as well as a valve cylinder, or even the main cylinder of a small engine, may best be made true inside by reboring in the lathe. If the character of the cylinder is such that it cannot well be fastened to the face-plate of the

lathe, then mount it on the slide rest and bore as hereinafter described.

Fig. 49 shows one of the many ways of mounting a small cylinder upon the face-plate of a lathe. Bolts and bands are all that are necessary, but considerable "know-how" is needed to get the cylinder in just the right position. Aside from the bolting there is the turning of the cylinder in two ways, so that the bore

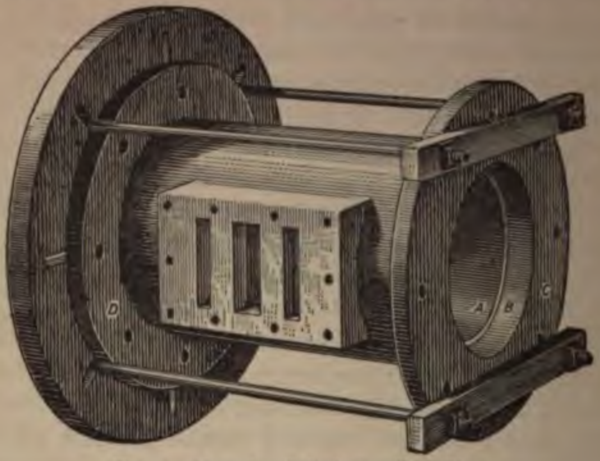


Fig. 49—Mounting Cylinder on Face Plate.

of the cylinder runs true and so that the flanges do not vibrate endwise of the cylinder in the least. After the cylinder has been bolted as closely as possible in a central position, put the chalk at work on the surface B, and make the sides of that space run as true as possible. So true, in fact, that no variation whatever can be detected.

It is also necessary that the flange C be so mounted or caught by the bolts that there is no danger of the flange being sprung. To this end, look closely at C, with the eye exactly in line with the flange, and see if there is the slightest wobble or "weave" of the flange to be detected. It is the inner bore A which is to be turned out, but the tool and the work must always be set by the surface B, which is a fraction of an inch larger in diameter than the main bore A. This enlargement of the cylinder is called the "counterbore" and is always found in cylinders of well-constructed engines. The cylinder head seats itself in this chamber, therefore the reboring of the cylinder does not alter the fit of the heads.

When all the shoulder has been removed between A and B then the limit of reboring has been reached.

A little thinking will show that the cylinder can be so bolted that one of the flanges, say at D, may be bent or sprung a trifle by uneven tightening of the bolts. It is also evident that the bending of one of the flanges might, and probably would, pull the counterbore B a little out of line to one side, so that the end D of the cylinder would be out of center and the new bore of the cylinder would not coincide with the counterbore at D, end of the cylinder. This is one reason why face-plate cylinder boring is not very desirable; it necessarily being impossible to caliper the

n f close work

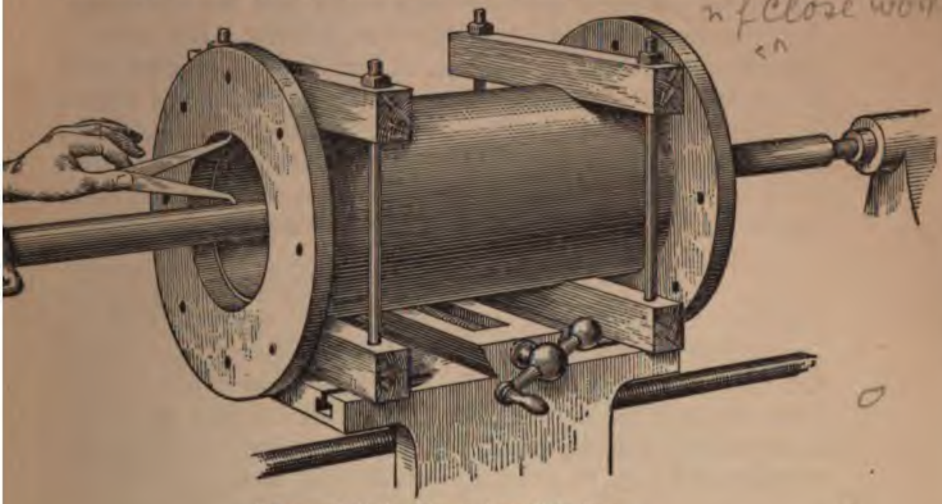


Fig. 50—Cylinder Mounted on Slide Rest.

flange D counterbore at the same time flange C is calipered. Therefore it is desirable to mount the cylinder for boring in such a manner that both ends may be gotten at for calipering. Hence the necessity for mounting the cylinder on the slide rest as shown by Fig. 50.

In this engraving it will be seen that the cylinder is placed upon two pieces of wood which have a circular place cut to fit the circumference of the cylinder. The cuts are deep enough to prevent the cylinder from rolling and at the same time to give bearing surface enough that the strain of the bolts does not distort the cylinder. Sometimes it is advisable, for this reason, to mount the cylinder by the flanges. In other cases even this will

exact no of threads

not do and the "plaster of paris" method is employed as described elsewhere in this chapter.

It is assumed that the cylinder will stand bolting, and the 4 x 4 inch blocks are cut to fit the cylinder, and also the cuts in the lower pieces are made just deep enough so that the center of the cylinder will coincide with the center of the lathe. Sometimes more than one trial is necessary to get the bottom blocks cut deep enough, but a little measuring will enable them to be cut deep enough without much trouble. It is well to cut deep enough so that the cylinder will lie a little too low, then build up to the desired height with sheet iron, paper or similar substances.

It will be noted that the bolts which hold the blocks and the cylinder are slipped into slots in the slide rest. If these slots are not present some other means of fastening the cylinder must be studied out. Frequently four bolt holes drilled and tapped into the slide rest will do the business. Centering sidewise must be done by means of slotted holes in the blocks above mentioned, and if the measurements are carefully made and followed there will be little or no need of much slotting of the holes mentioned.

CENTERING THE CYLINDER.

Once the blocks are in place and the bolts tightened with the fingers procure a pair of inside calipers and proceed to adjust the cylinder centrally with the boring bar which has already been put in place between the lathe centers. Fig. 50 shows in a general way the method of fastening and calipering the cylinder, and Fig. 51 gives a more detailed idea of the proper way to perform this important operation—perhaps the most important one of the whole, for if the cylinder is not very accurately centered with the boring bar all subsequent operations will be of little value because the entire engine will be out of line when again assembled, unless the new bore of the cylinder is exactly true with the counterbores at either end of the cylinder.

With the calipers as shown by Fig. 50 measure the distance on top of the boring bar between it and the top side of the counterbore, then, without changing in the least the distance in the calipers, measure between the bar and the bottom of the counterbore. The measuring should be done with the calipers held exactly vertical, something as shown at B and in D, Fig. 51. If the measuring is done in the directions shown by the

letters in question, then any vertical adjustment which may be made to the cylinder will not affect the lateral adjustment. Should it be found that the calipers as adjusted at B will not fill the space D, then the cylinder must be raised slightly by packing under one or both of the wooden blocks by which the cylinder is

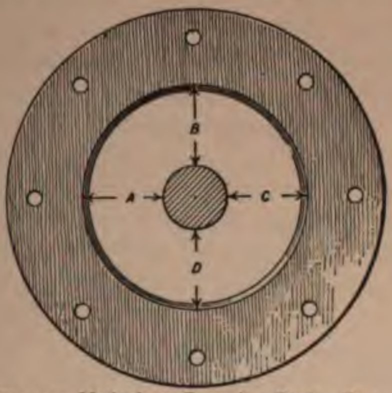


Fig. 51—Method of Centering Boring Bar.

fastened to the lathe. After a reasonably close adjustment is made as above directed, proceed to caliper the spaces A and C and equalize them in the same manner, moving the cylinder sidewise by means of the slots in the wooden blocks, already described.

It is always well to make a rough adjustment, say within 1-16 inch in both vertical and horizontal directions at either end of the cylinder before attempting the finer adjustments. In fact, this rule should always be observed. If the calipering be done as nearly vertical and at right angles thereto as possible the adjustment will be much more simple than if the calipering be done at E and F, for the reason that the calipering should be always done in the line of possible adjustments, which are vertically and horizontally with the cylinder-fastening arrangement, used in this instance. Were the cylinder held at any other angle, then the calipering should be done at that angle and perpendicular thereto.

THE CALIPERING.

Calipering, in itself, is almost an art. Upon it depends the accuracy of almost every machine-shop operation. To do good calipering requires long practice and the use of brains. A few

fundamental directions only can be given here regarding a matter which should have an entire chapter devoted to it, but the matter is so extensive that it must be treated elsewhere. To begin with, always hold the calipers lightly yet firmly, and hold them in a vertical position. Fig. 52 shows that the calipers must always be held straight away from the center of a shaft when calipering anything outside of that shaft, and the same holds good when calipering the inside of a hole. In a round hole the calipers must pass through or toward the center every time, and invariably they must stand at right angles to the surface which is being measured from, and this is true no matter whether the surface is flat or curved.

But there is another direction in which the calipers can be wrongly held, and which will give incorrect readings to the measurement. This way is shown by Fig. 52, the incorrect method

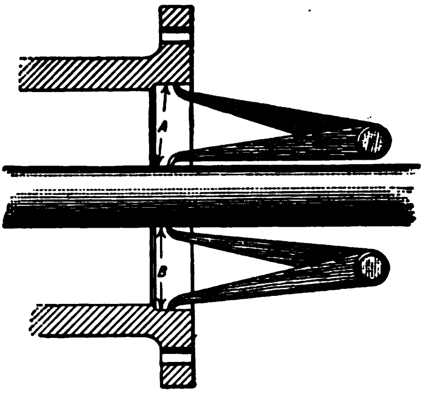


Fig. 52—Bad and Good Calipering.

being shown at A, the correct method at B. In this, as in Fig. 51, the points of the calipers must stand vertical (perpendicular) to the surface to be measured from. In other words, the caliper points must stand "straight up" from the surface which is being calipered from or to. It is readily seen that the distance A shown by the calipers is greater than that shown by B, hence if one side of the cylinder is calipered to the boring bar like A, and the other side be calipered like B, then the boring bar will not be in the center of the cylinder, no matter how much calipering is done.

When very thin cylinders have to be chucked, and when the clamps might spring the walls of the cylinder out of shape, then it is well to mount a box on the slide rest as shown by Fig. 53,

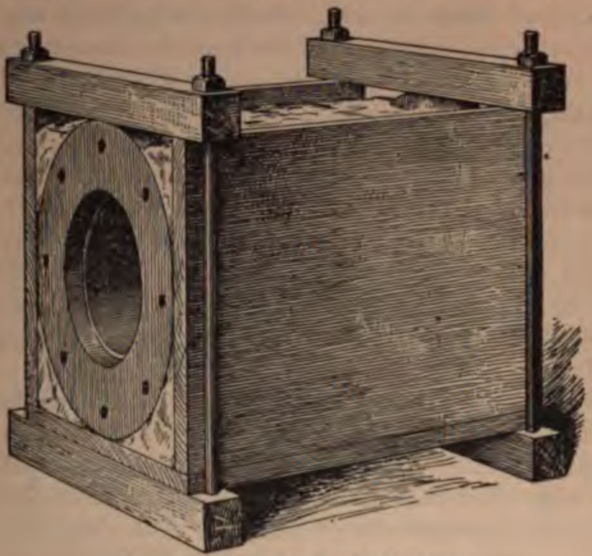


Fig. 53—Setting Cylinder with Plaster.

block the work in exact position, then pour in plaster of paris (calcined plaster) until the work is covered. The plaster will hold the work securely, but no adjustment can be made except by moving the box and blocks bodily, vertically or laterally. When very thin shells are to be bored, like pieces of tubing, the cutting action of the tool frequently causes the sides of the tube to spring or buckle, resulting in a very uneven bore. This tendency to distortion is cured by the plaster backing, which holds the work most securely. When such thin pieces are to be bored or turned a small stream of water should be made to run over the cutting edge of the tool continually while the tool is at work. A small pipe leading into the hole to be bored will serve to conduct the water to the working point. A very small stream, scarcely larger than a needle, will prove amply sufficient for this purpose.

CHUCKING WORK WITH PLASTER.

When mixing plaster for setting a cylinder do not be afraid of getting the mixture too thin. Thick stuff like mortar will not answer the purpose, although a very small portion may be mixed

to that condition and used to plaster up the outlets in either end of the box around the flanges of the cylinder. When there are considerable spaces to be filled, and plaster is scarce, build up a little wall with pieces of iron, nuts, bits of scrap, or any bits of metal which come handy, using thick plaster as mortar and the bits of metal as bricks. Indeed. pieces of brick may be used to advantage for this purpose, their only object being to save plaster in closing the end openings.

With every opening closed except at the top, mix the plaster thin like cream, and pour it into the box until the cylinder is completely covered. If the plaster does not readily run into every crack and crevice, then the mixture is too thick and will not do a good job. Mix the plaster by pouring plaster into water, stirring smartly all the time. Do not try to mix by pouring water into a box of plaster.

When an ugly job has to be supported on the face-plate of a lathe, plaster can frequently be used in connection with a few bolts, the latter serving to anchor the work so that it cannot get away; then build up under unsupported parts with plaster, which for this purpose should be mixed thick enough to "stand alone." If, for any reason, there be required considerable time for the adjustment of the work while the plaster remains soft, then mix with vinegar instead of water, or put a lot of acetic acid into the water used for mixing the plaster. This substance delays the setting of the plaster and gives a chance to use it like putty for a considerable time, whereas if mixed with water it would have been set solidly in a fraction of the time.

TOOLS AND "JIGS."

The lathe in itself is a most useless appliance. It can be used only as a convenient means of applying to work a number of tools and "jigs." Nobody can do any work with a lathe. That machine would stand idle forever were it not for the little tool which gets busy with the metal placed between the lathe centers. Take this view of the case, Mr. Blacksmith, and don't rely upon the lathe for an increase in your business. Instead, just get busy and devise a lot of special tools which you can use in the lathe in order to turn out lots of work.

Doubtless you have a power drill in the shop, or will have as soon as the lathe is set up. It is too bad to do drill work in a

good lathe—too big a club to kill a little mosquito with, but drilling can be done in the lathe—lots of it, and good drilling, too. Some chucks will be required for holding the drills, and you can buy any one of half a dozen good makes of drill chucks, or you can make some excellent drill chucks and fit the drills to them.

No matter whether the chucks be made or bought, make them interchange between lathe and drilling machine. It only requires a very simple tool like that shown in Fig. 54 to do the business. A bit of steel shaft turned to fit the taper hole in

Fig. 54—Drill Chuck.

spindle of lathe or drill, then if it be for the lathe, put it in place in the spindle and proceed to drill the hole to fit the shanks of the drill to be used. If there are several sizes of shanks, make as many chucks as there are sizes. If the drill or lathe be purchased from the maker, have the hole in spindle of each made to suit your requirements, and if the holes are not alike after the machines arrive in the shop it is often possible to make a reamer to fit the lathe spindle taper and ream out the hole in drill to the size of hole in lathe spinde.

When it is not convenient to do the reaming act, make two special chucks, one for drill, the other for the lathe, and ream each to fit the other. By so doing all the tools for either drill or lathe are at once made interchangeable and may be used at will in either machine.

It is necessary to provide chucks for holding large drills and small drills also, and a very good way to do it (if store chucks are out of the question) is to make a small chuck for the little drills and fit the small chuck right into the big chuck shown by Fig. 54. This settles the interchangeable matter at once, and it is a very handy way for the reason that when a small drill and a large one are to follow each other in use it is not necessary to remove a taper shank chuck from the lathe. All that is necessary to make the change is to loosen the

set-screw in chuck (Fig. 54), remove small drill chuck and put in large drill. It is presumed that the drills and the small chucks all have straight shanks, while the holes in drill and lathe spindles are tapered.

The smith should use "jigs" in lathe work or in drilling, whenever possible. A "jig" is a simple device for holding work while a tool is acting upon it and should be so constructed that the different pieces of work acted upon while in the jig will all interchange with each other as far as the work done is concerned. For instance, should it become necessary to drill holes exactly similar in size and location in the ends of many pieces of bar iron, say 3/8 x 1 1/4 inch for a fence, a jig should be used by all means. It would not pay the smith to lay out all the holes with center punch, hammer and rule and then drill each hole to the mark thus made. That would be "making" the fence. The smith should "manufacture" the fence, therefore he selects three or four bits of iron, drills a few holes in them and arranges stop pins and a clamp bolt to hold the pieces of iron under a guide hole (steel bushed if many holes are to be drilled), which causes the holes to all be located alike. This is a "jig."

CHAPTER XII.

TURNING WOOD IN THE IRON WORKING LATHE.

The average machinist is not a phenomenal success as a wood turner, and it is not to be expected that the smith has extraordinary latent talent in that direction, still, by the use of a small amount of brain matter both the machinist and the smith will be

Fig. 55—"Scraping" Wood.

able to turn out almost any job which may come along. Do not get the idea that wood can be profitably turned with ordinary lathe tools. It is true that a piece of wood may be turned to any desired size and shape in the lathe, exactly as a piece of iron is turned, but it is not profitable to do so.

Wood turning requires a much higher surface velocity than metal turning, and the average screw-cutting lathe is not speeded fast enough to do good wood turning on very small diameters. Even the highest speed used for filing, polishing or drilling is not fast enough for working wood of the same diameter, therefore, if the smith desires to add wood turning to his machine work, a special pulley must be provided in order to give the necessary speed. In fact, for turning wood shapes from one to two inches in diameter the lathe spindle should run about 1,000 revolutions to the minute.

For turning rolls five or six inches in diameter the iron-working lathe answers very well, and the speeds can be adjusted

to suit. The great secret of wood turning is to cut the wood, not to scrape it, as most machinists and patternmakers do, as the writer is forced to testify. Nine men out of ten, in attempting to cut a piece of wood in a lathe, will present the tool as shown by Fig. 55, so as to take a scraping cut, when Fig. 56 shows the

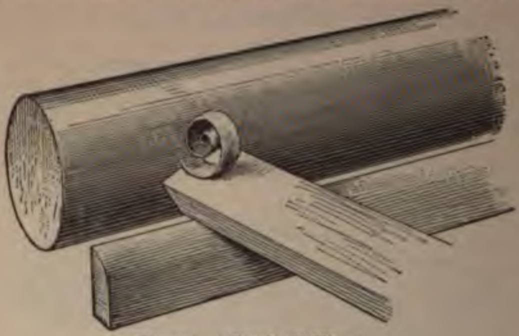


Fig. 56—"Cutting" Wood.

proper way. "Don't scrape if you want to turn" is the proper maxim for the wood turner, be he machinist, smith or any other man.

For roughing out work, say for large rolls or any other jobs which have considerable straight surface, the tool shown by Fig. 57 is the proper one to use. The diameter of the bend may be

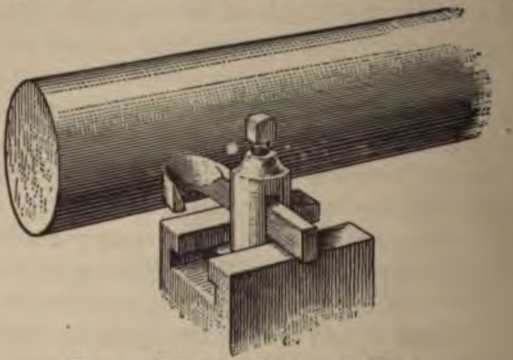


Fig. 57—Slide Rest Wood-cutting Tool.

larger or smaller, according to the size of the work to be done. Bent around a ¾-inch rod gives a tool suitable for rolls of 4 inches to 8 inches in diameter, and by bending around a 2-inch form a tool will be secured which gives satisfaction on work up to 24 inches to 36 inches in diameter. In bending the tool, also in its

forging, great care should be taken that the outside of the bend is at right angles (square) with the top and bottom edges of the tool. It is not the inside of the bent portion which should be made thus square, but the outside portion.

Fig. 58 shows the method of grinding this form of tool. The face, B C, comes next to the work and is made square with the length of tool as above, and the cutting is done at C. When grinding is necessary it is done at C, until the face B C is gradually worn away to the line A B. This is about as far as grinding can be carried, and a new tool should be made when the wear approaches this line. The inside of the tool is never ground. It is filed up when the tool is made, before it is hardened and finished with an Arkansas slip. The smith should have several of these very useful stones. They come in all sorts of shapes and sizes and may be obtained from any dealer in hardware and tools. A couple of round slips will be necessary for whetting the tool shown by Fig. 57; one stone ¾ inch in diameter and another 1 inch through will answer. If a ½-inch stone be also added the variety will be as great as will likely be called for. The smith can also find use for a three-cornered stone, one with a knife edge and two or three flat stones of different widths and thicknesses. They are very handy things to have and cost but a trifle.

Fig. 58—Grinding Wood Tool.

When the tool shown by Fig. 57 is used for turning rolls it should be set square against the wood and made to take a cut in either direction. That is, do not run the carriage back by hand, but reverse the feed and make the tool cut on the return trip also.

INSIDE AND OUTSIDE TURNING TOOLS FOR SLIDE REST WOOD TURNING.

The tool shown by Fig. 57 is an all-around tool which may be used for almost any straight outside work. As for inside work in wood, there is very little of it which the smith will ever be called upon to do. Perhaps the making of rolls for moving houses will call for a hole through the center of each roll in order that the seasoning of the wood may not crack the outer surface full of season checks. A small hole through the center or axis of the roll will prevent prevent this, and the hole must be made when the roll is turned.

For the purpose noted above nothing is better than the old-fashioned "pod auger," as shown by Fig. 59. This tool is easily made by the smith, and the size may vary from 1 inch in

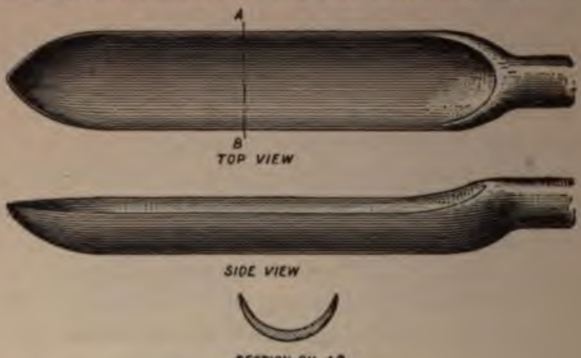


Fig. 59—The "Pod Auger."

diameter to even 6 inches if pump logs have to be bored. This tool is easily made by welding a bit of steel to the edge of a piece of flat iron, and then plating out and forming up as shown by the engraving, after which the tool is welded to a round shank of sufficient length to reach through the longest piece to be bored, and with additional working length to permit of its being held in a chuck.

There are two methods of using tools of this kind: one way is to catch the shank in a chuck placed in the tail spindle, and mount the roll on the face plate or in another chuck. When this is done the free end of the roll is usually held by means of a hollow center, the diameter of which is the same as that of the pod auger. The hollow center is placed in the tool post and the slide rest brought up and held by means of the lead screw. The hollow center furnishes a support and guide for the auger.

The other way is to mount the roll in V notches (blocks of wood placed across the ways of the lathe) and put the auger shank in the spindle chuck. In this case the roll is fed against the auger by means of the tail spindle and a block of wood should be placed between to prevent damage between auger and tail spindle.

TURNING UP PATTERNS.

A considerable amount of pattern work must necessarily be done by the smith if he expects to do any machine work. Fre-

quently a good deal of machine work can be avoided by a skilful arrangement of the pattern, and many patterns must be turned up in the lathe, and tools and the "know-how" are necessary for this kind of work as well as for lathe work.

Probably the smith is well acquainted with the "dog" used by wood turners for holding work in the lathe. Fig. 60 represents the most common variety, which is made by turning up a shank to fit the lathe center, drawing the end to a wide V shape, and then filing at A and A so as to leave a central point and two wedges,

Fig. 60—Wing Dog.

one on either side of the point. This is used as a live center and is driven into the wood sufficiently to rotate it.

An ordinary center is used and the rig is all right for hard wood, but is very apt to drag out of place in soft wood, provided much heavy work is to be done. A much better center for soft wood can be very easily made by the smith. Fig. 61 shows how the blank is turned up, and Fig. 62 illustrates how the teeth are cut with a file and a hack saw. Any number of teeth can be made as desired, so that the dog may be given as much holding over as may be found necessary.

Fig. 61—Making a Star Dog.

It will be noted that the conical center is left much longer than the teeth. This is for the purpose of letting the work be placed between centers while the lathe is running. When a large number of pieces have to be made, the time lost in stopping to put a new piece of wood in the lathe is considerable, and the long center permits of the work being placed between the centers and then the tail stock may be run forward, thus holding the work securely.

Fig. 62—Star Dog, Complete.

The tail center to accompany this form of dog is made in the

same manner, only the ring at the end is turned thin, as shown in section by Fig. 63, and is left whole, in a continuous ring, instead of being cut into teeth as was the case with the soft wood dog, Fig. 61. An improvement of considerable worth may be made in centers of this kind by drilling the oil hole shown at A. Fig. 64, whereby the inside of the cup ring may be lubricated. The hollow center noted above as fitted to the tool post for use in turning and boring rolls is made in the same way as shown by Fig. 63, except the center is missing and a hole is bored through that point large enough to receive the pod auger described elsewhere.

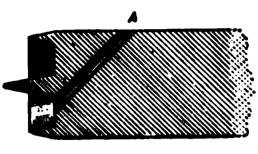


Fig. 63—Cup Center.

Usually, pattern work requires a considerable quantity of face-plate work, and small face-plates should be duplicated, several being furnished, or made as noted in a previous chapter. One small face-plate should have a screw, projecting from ½ inch to 1 inch, in the middle of the plate, as shown by Fig. 64. In using, the bit of wood is simply screwed hard against the face-plate, where it is held by the screw sufficiently secure for turning purposes.

This method of fastening answers very well for small objects from 1 to 2 inches thick and less than 6 inches in diameter. For larger work another chuck or face-plate should be provided, similar to that shown by Fig. 64, but with the exception that the screw is omitted and four holes drilled through the edge of the plate as shown by the engraving in question. Indeed, the holes may be put in the screw-plate and for large work the power of the central screw is reinforced by as many common wood screws, put through the holes, as may be found necessary to hold the work in place.

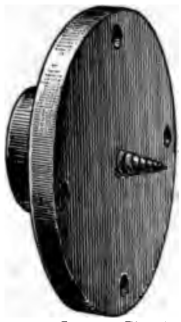


Fig. 64—Screw Chuck.

Suppose, for instance, that the smith desires to make a pattern for a simple set collar to go on a 1 15-16-inch shaft. This object is merely a ring of cast iron bored to fit the shaft and fitted with a set-screw to hold it in place. Fig. 65 shows one of the face-plates with a bit of soft wood fastened in place by two wood screws driven in from the back through the holes mentioned in the preceding paragraph. In this illustration a tool

rest fixed in the tool post is represented at A, the block screwed to the face-plate F, and two tools, B and C, are shown, one in

Fig. 65—Making a Collar Pattern.

position for inside cutting, the other for outside work. In practice the tool would be used at C first, in order to remove the rough corners, thereby permitting the work to run smoother than possible with the corners on. After the corners have been taken off a light cut should be taken to make sure that the work is exactly true, then the tool may be shifted to position B and the inside of the pattern worked out.

It will be noted that both the tools shown by Fig. 65 are in position to take a scraping cut, notwithstanding the remarks made in another paragraph against this very method of cutting. However, it is necessary to take scraping cuts in a good deal of pattern work and in working to exact dimensions. While scraping is permissible in this kind of work, to a certain extent, it should never be practiced or tolerated in straight turning.

The tool shown by Fig. 65, and in detail by Fig. 66, is a very handy one for either the wood turner or the machinist. The

Fig. 66—Two Handy Hand Tools.

tool is easily made from a bit of square tool steel ⅜ inch or ½ inch square. One end of the steel is drawn to form a

shank and is fitted with a more or less elaborate handle—usually less—and the other end needs nothing except grinding, as shown by the sketches. A is a side view of the grinding while B shows a side view of the tool looking over the top. If the smith does not catch the idea from that sketch, then turn the tool so one corner will come exactly upward, and in that position apply the tool to stone or wheel and grind a nice, clean bevel as shown. This tool works equally well on wood or metal and is a very handy addition to the kit of either smith or machinist. For metal working the tool should be hardened a little more than for cutting wood, but once fixed for iron or steel working the tool may be used for wood without changing the temper.

LABOR-SAVING JIGS AND ATTACHMENTS.

Turning taper work is one of the things which often has to be done and which requires a good deal of ingenuity on the part of the operator. If a piece 2 inches long on a 20-inch shaft has to be turned to a taper of 1/2 inch to the foot, then the smith-machinist is in for quite a bit of figuring. The best the smith can do is to "set over" the tail stock enough to bring the desired taper. One-half inch to the foot taper means 0.835 inch in 20 inches, therefore the tail stock must be set over that amount and the work put between centers and the turning done in the same manner as if the shaft were perfectly straight instead of tapered.

It is quite easy to arrange a taper attachment to the lathe in such a manner that not only that taper turning be readily done, but that taper boring may be just as easily done. The way referred to is to mount a straight steel bar on the back side of the lathe, and arrange bearing so that the bar may be adjusted and fastened at any required angle with the lathe bed. Next arrange a slide to fit the bar, with an adjustable gib to make a close fit, then attach the slide to the back end of the slide rest and remove the cross-feed screw from the slide rest, which will then be entirely controlled by the bar and slide on the back of the lathe and as the carriage moves toward and away from the head stock the tool moves to or from the center of the work. This arrangement, which is attached to some lathes, will enable taper pins to be made accurately, and it can also be used for boring taper holes which the pins made will surely fit.

With the bare lathe, if the smith has need to bore a taper

hole, he surely is "up against it." About the only thing he can do is to count the number of turns the cross-feed screw must make to move the tool through half the amount of taper. Then, with a similar counting or calculating of the number of turns or revolutions the spindle will make while the tool travels along the distance to be tapered, the smith is able to find out just how far to turn the cross-feed handwheel during each revolution of the lathe spindle. For instance, it is desired to turn a taper of ½ inch to the foot in a hole 3 inches deep. The bore means that in 3 inches the taper will be one-fourth of ½ inch, or ⅛ inch. As half the taper is on either side of the hole, one side should have a taper of 1-16 inch in 3 inches. Allowing that the feed of this particular lathe is 64 to the inch, then the cross-feed screw being 12 threads to the inch, it is evident that the cross-feed handwheel must be turned 12-16 of one turn, or ¾ of a revolution while the lathe spindle is making 3 x 64 turns. In other words, the handwheel must be turned one-fourth a turn to each inch of hole to be bored. The task now becomes an easy one. The smith-machinist can easily divide up the stated circumference into 64 imaginary parts and then turn the wheel one of those parts at every revolution of the lathe spindle. In taking the roughing cuts it will be necessary to feed only once in three or four revolutions of the spindle, advancing the feed, of course, three or four spaces each time, instead of a single space as when feeding each time the spindle revolves. In this way the lathe can be made to turn or bore a mighty slick taper without any taper attachment, or without sending the apprentice for a can of "taper oil," or without "throwing the tail end of the lathe around" with a crowbar.

OTHER TOOLS TO BE ADDED WITH PROFIT.

There are a great many appliances, jigs and fixtures which may be added to or used in the lathe with considerable profit to the owner of that machine. The smith can rig up jigs whereby he can do milling in the lathe, he can add a planing attachment and he can also make the lathe do gear cutting, polishing and a dozen other things. Indeed, an "amateur" of the writer's acquaintance had a fine lathe to which he had added by purchase or by his own make over twenty attachments for performing as many entirely different operations. The smith will find that it

does not pay to carry this business too far. Remember that all the money earned for him by a lathe is by the work turned out, and if too much time be spent in changing attachments or in "rigging up" much less will be earned than if the lathe be kept at work all the time.

The smith can easily arrange the lathe so that it will cut up round iron in mighty good shape. It costs very little to so rig a hollow spindle lathe, and the manner in which the pieces drop off is good to see. Still, however good to look at, the arrangement does not pay. The smith has $200 at least invested in that lathe and he can keep it busy all day, charging 60 cents each hour at least for the lathe and a man to run it. It therefore costs 60 cents an hour to cut off iron, besides the interest on the investment and some other things. The lathe is also tied up and is kept from its proper work.

How much better, then, it is to put in a little power hacksaw, which costs about $75, and which may be started by a boy, and which requires no attendance at all while running, and which stops as soon as the piece of metal is cut off. Just figure how far that 60 cents an hour would spread itself out on the cost of running the power hacksaw. In addition to the decrease in cost of cutting off, the lathe is all the time earning its profit otherwise, instead of being tied up to the work of a $75 machine.

The same is true in other directions. Do not load up the lathe with "attachments" for doing this and that. Rig up special machines. Cast iron is cheap and it costs little more to rig up a stand and a shaft and bearings than it does to accommodate some special machine or arrangement to the lathe.

It is the special machine which pays the most, and the more special machines the smith can make and keep at work all the time, the more money he is making. Write it down, when making a special machine, that the cost of that machine ceases when it is completed, and that its output is clear gain, and that you will not have to deduct therefrom the time spent in adjusting "attachments" to the lathe, neither will you have to make any allowance for time spent while you were rigging it up and using it as a special machine.

The smith should have a vertical drill in the shop, and he is entitled to that tool even before he arrives at the dignity of a lathe. The next tool purchased should be the power hacksaw,

then a shaper, next a milling machine, with all the special machines sandwiched in between. By the time the above-mentioned tools have been added the shop will have become too important to be called a "smith machine shop," and the machine part must be made a department by itself.

CHAPTER XIII.

MAKING A "QUARTER-TURN" CRANK SHAFT.

By a "quarter-turn" crank shaft is meant one which has two wrist-pins at right angles to each other, or 90 degrees apart. Fig. 67 represents a crank of this character and it is about as it is proposed to make the shaft to be described below. The dimensions of the shaft will not be given, that data being supplied by the smith-machinist in accordance with the particular demands of the case in hand.

Do not attempt to make a crank shaft, or any other piece of machinery, without first making a drawing or at least a sketch of it, showing the work as it is to be when finished. It is very

Fig. 67—Quarter-turn Crank Shaft.

easy to get into the "sketch habit," and it is of great value to any mechanic. It saves a lot of trouble from misunderstanding, and totally obviates the necessity for any "cut and try" work whatever.

Referring to Fig. 67, it will be noted that the two cranks, A and B, stand at right angles to each other or, in draughtsman's language, they are 90 degrees apart. It will also be seen that there are three separate and distinct centers in the crank. One, the main center, and two others, one for each crank. These centers must be most accurately laid out and drilled, for upon their accuracy depends the truth of the entire piece of machinery.

There is a center in each end of wrist A, and two other centers in wrist or crank B. If either one of these centers departs even so slightly from its accurate location, then there will

be one or more defective wrist pins which can never be able to run true or cool.

GOOD AND BAD FORGINGS.

The first thing, after the drawing of the crank shaft is made, is to obtain the forging or "blank." Fig. 68 shows a well-forged

Fig. 68—Blank Forging for Quarter-turn Crank.

blank with the crank blocks turned at approximately 90 degrees with each other. And it is wonderful how closely a good machine blacksmith will come to getting things exactly right. It used to be a standing joke in the shop where the writer learned the machinist's trade that when a man did a bad job the foreman would gravely remind the man that he must do better if he stayed in that shop, for "the blacksmith downstairs can forge closer than you can turn with a lathe." And there was a good deal of truth in it, too.

Anyone who has had a great deal to do with automobiles has noticed the frequency with which the crank shafts break. A flood of light was turned on that matter the other day when the writer happened to be in a large shop where they were turning out automobile cranks by the hundred on contract. These blanks did not look the least like the one shown by Fig. 68; instead of that the blanks presented the appearance indicated by Fig. 69,

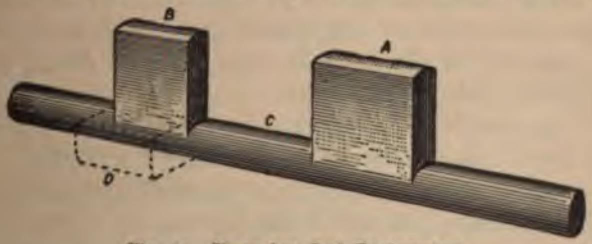


Fig. 69—Cheap but Bad Engineering.

both cranks being forged on the same side—a much easier operation—and then the shaft was twisted as indicated by the dotted

lines, to bring the cranks to a quarter turn. It certainly cannot make a crank any stronger to twist the shaft between the wrist-pins, and the writer is of the opinion that many more of the twisted cranks break than of the forged angle crank shafts.

CRANK SHAFT JIGS.

Having secured a forging, made to suit, the next thing is to lay it out and put it in the lathe and begin to finish the article. It is best to make a couple of jigs for use in making these shafts, and the jigs in question will more than pay their cost in the one job which we are going to take in hand. Fig. 70 shows one of these jigs, but they may be made in many different forms,

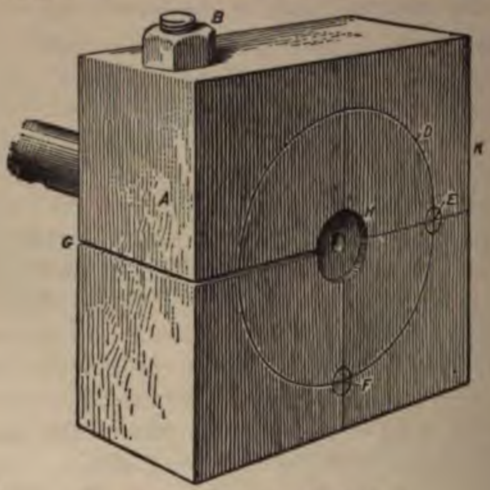


Fig. 70—Jig for Turning Crank Shaft.

the only requirements being that it is possible to clamp the jigs firmly upon the ends of the crank shaft in such a manner that the jigs will not slip or yield in any manner during the entire machining of the crank shafts.

This jig consists of a square cast iron block, A, with a carefully bored hole at H to fit the end of crank shaft C. After the jig is otherwise finished a slot is cut at G with a hack saw, so that by tightening the nut B the jig may be clamped firmly upon the crank shaft—so tightly, in fact, that the jig will not slip or move during all the turning and filing operations upon the shaft.

It is necessary that at least two sides of jig may be made square with each other, and also with the face on front side of the jig. It may save a little labor if the sides, K and J, be squared up after the hole H and the centers E and F are made. To proceed in this way chuck the jig block, which may be of plain cast or wrought iron or steel, and bore the hole H. Then mark the circle D very accurately with a pointed tool held fast in the tool-post, make the distance of circle D from center of H exactly to the throw (length) of the crank. Take great care in making this circle, for upon its accuracy depends the accuracy of the crank shaft. Two of these jigs must be made, one for either end of the crank shaft, and it will be well to omit circle D until both jigs have been finished; then put one of the jigs, or both of them upon opposite ends of a short shaft of the exact diameter of the proposed crank shaft, and clamp the jigs tight. If a short shaft is not to be had, use the crank shaft, turning up each end enough to receive the jigs.

USE A SURFACE PLATE.

In clamping the jigs to the shaft they should be laid upon a surface plate. Anything will answer that is smooth, true and hard. Surface plates may be purchased from any dealer in machinists' tools. A plate 12 inches by 18 inches will do nicely for the machinist, and will prove a paying investment. In fact, a surface plate and a surface gage (see Fig. 72) are absolute necessities for doing good machine work. Any smooth, true surface of planed or turned cast iron will answer for a surface plate, and for a substitute the large face-plate may be used, but it is not nearly as satisfactory as a regular surface plate.

Referring again to Fig. 70, it will be noticed that vertical and horizontal lines pass through the center of hole H, and through centers F and E respectively. These lines must be accurately made, and there are at least two ways of making them. Either the lines may be made before the hole H is made, and the hole H accurately drilled where the two lines cross, or hole H may be drilled, the jigs placed on the shaft which is squared up as shown at G, Fig. 71, and the lines drawn by means of try square and surface gage.

The front end of each jig must be machined or filed smooth, after which the circle D and the vertical and horizontal lines

may be drawn as follows: Dissolve some sulphate of copper (blue vitriol) in a little water and rub some of the solution over the bright surface of the jig ends. Allow to dry, and a film of copper will be found deposited on the iron. The film of copper shows a scratch mark very plainly and lines are easily drawn upon the surface thus provided. The surface gage H, Fig. 71, should be used for drawing the horizontal line at E, Fig. 70, through the center of each jig, and the vertical line F may be drawn by means of the try square, G, Fig. 71.

LAYING OUT A SHAFT.

Fig. 71 shows how the shaft, with jigs in place, is laid on the surface plate, and the jigs made to bear evenly and fairly upon the plate, also to stand square with the plate, as at G.

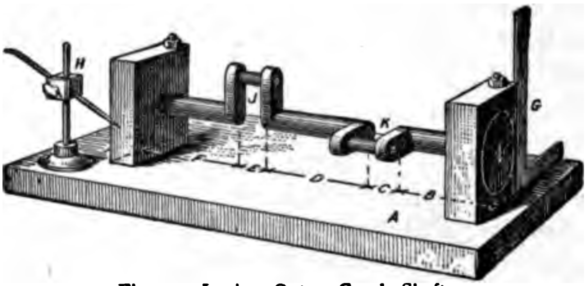


Fig. 71—Laying Out a Crank Shaft.

The curved point in the scriber in the surface gage H is used for testing to see that the lower edge of crank shaft is equally distant from the plate at all points, the gage being set to one end of shaft, then moved to the other end. When everything is all right and the crank, C, lies exactly parallel with the surface plate, then the line through E of Fig. 70 may be drawn in the copper film on each of the jigs, and where this line intersects with circle D, there is the place for one of the centers to be made. The other center, F, may be determined in the same way, but with try square G, Fig. 71, instead of the surface gage illustrated by Fig. 72, which will be described later on. The smith should supply himself with two surface gages, one small, the other, a large one, but get the small one first.

Fig. 71 also shows how the lengths of the various parts of the crank shaft are laid off. These points for the lathe worker to work to the shaft blank, using the copper solution on bright

metal or common white chalk on rough surfaces. In turning, the lathe worker has only to cut up to these marks and then stop.

SURFACE GAGE.

The surface gage, shown in Fig. 72, is a necessary tool when work is to be laid out. It can be purchased ready made, but would advise the repair man to make it. He is obtaining a good tool and learning something of greater value than the tool. If there be no time for tool making, then buy, by all means, but it is only in extreme cases that a man cannot find time to make himself a good surface gage. To make the surface gage shown in Fig. 72 obtain a piece of metal something like cast iron, about 2½ or 3 inches in diameter. Then turn up to any fancy shape desired. Drill for the rod C, which is about 3-16 inch in diameter and made of steel; tap in thumb screw B to hold C in place. The block, D, is made in two pieces, one of which slides upon C, and is clamped to it by the thumbscrew. The scriber, G, is of ⅛-inch steel with end, H, curved. The thumb-screw, F, clamps G into the block, and clamps the two blocks to-

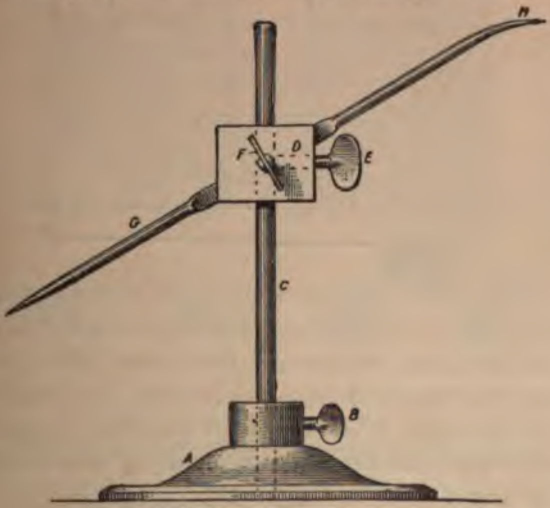


Fig. 72—Surface Gage.

gether. The scriber may be turned in any direction vertically, and by sliding block D it may be placed at any required height above the surface plate.

By setting point G to line E of Fig. 70 and then sliding the gage to the other jig it will be shown at once whether or not

the lines E on both jigs are the same distance from the surface plate. If not, the lines must be mended.

DRILLING CRANK CENTERS.

Having found that the center marks on both jigs prove true by means of tests with surface gage and try square, the four crank centers (two on each jig) should be drilled and countersunk. This is a job which calls for the highest skill of a good machinist. Fig. 73 shows how to do it. Around the quartered crank centers small circles are drawn to the exact diameter which it is desired to countersink the center. These circles are

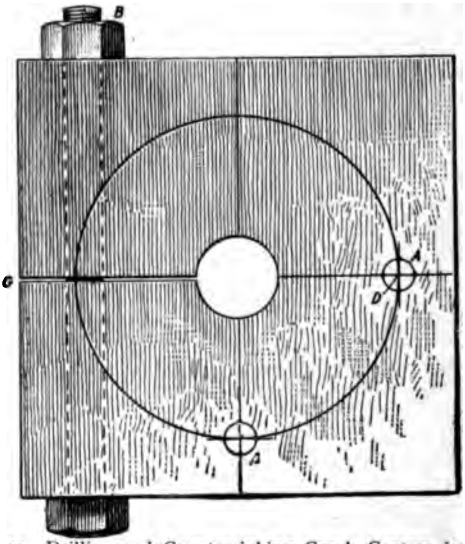


Fig. 73—Drilling and Countersinking Crank Centers in Jigs.

shown at A and A, and they are further marked by four or more center punch marks equidistant from each other, as shown in Fig. 73. The object of these punch marks is to enable the mechanic to determine when the countersinking is going right, and to make sure that the tool is not cutting to one side, instead of straight ahead.

A small drill is started at D and is run in as far as necessary, clearing the lathe centers as described in Chapter IV. When ready to countersink the small drill hole there is no guarantee that the countersink will cut the same on each side of the center. Indeed it almost always runs to one side, as at A, Fig. 74. Either the metal is softer on side of hole A, or some pressure

causes the drill to cut that side farthest. At any rate, the hole goes toward *a*, and our business is to correct it. All changes must be made before the straight portion of drill on countersink gets to work. In countersinking, this must be done anyway, as only the point of the tool touches the work.

With the hole started nearest *a*, Fig. 74, it is necessary in order to make a decided change in the direction of the hole, to cut a channel, as shown by *e* at B, using a small cold chisel for that purpose. If the proper amount be chipped out, the hole will straighten up when drilled a little more, taking the position shown at C. In this condition the countersink is correct and should be continued until its edge just touches the limit circle all around, as shown at D, when countersink may be stopped with every assurance that the centers are finished as accurately as is necessary.

ROUGHING OUT AND FINISHING.

With the jigs once properly drilled and countersunk, give them a final surface gage test to see that they are perfectly square with each other and with the shaft and proceed to rough out the crank shaft. It is well to cut out some of the metal between the arms of each crank before the shaft is put in the lathe. If in a regular machine shop, the cranks would be clamped together and the chunk of metal cut out on a shaper. As there is no shaper at hand, drill a row of small holes ¼ or ⅜ inch around the piece to be cut out, and finish the job with a hack saw. If the

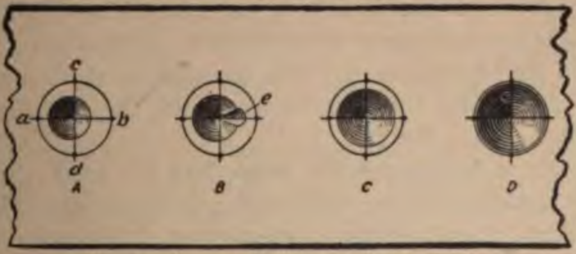


Fig. 74—Accurate Drilling or Countersinking.

smith has arrived at the understanding of the proper value of milling cutters, then he will clap a cutter on an arbor, clamp the crank shaft to the slide-rest, and mill out the square bit of metal in a hurry.

Do not take a finishing cut over any portion of the crank shaft until all has been roughed out and worked down close to size. It is extremely probable that more or less straightening

will have to be done to the shaft, as the turning proceeds, for it is usually found to be the case that a piece of metal changes shape when the outer portion or skin is removed. Therefore, rough out the shaft, turn down nearly to the finishing cut, then test again upon the surface-plate and apply the necessary corrective straightening that may be necessary.

To turn the wrist-pin of any crank, simply put the lathe centers into the centers in the jigs which correspond to that particular crank, then go ahead and turn up the surface concentric with the center, after which another pair of centers is brought into use, etc.

STEADY PIECES.

Referring again to Fig. 71, two pieces of metal should be squared up and fitted accurately between the arms of each crank at J and K. These pieces take the strain off the wrists during the several turning operations.

These "steady pieces" of metal should never be driven tightly into the cranks. If they be thus driven, a strain will be set up which will surely cause the cranks to be crooked when the steady pieces are removed. Contrawise, if the pieces are fitted too loosely, the crank will pinch them when in the lathe; then the reverse spring of the shaft when it is removed from the strain of the lathe will cause the shaft to be crooked in the opposite direction from what it was when the steady pieces were too tightly placed. Thus, these pieces should be very accurately fitted. They should be made preferably in two pieces and fitted to slide easily between the cheeks or arms of the cranks. Then a piece of paper should be placed between the two pieces of metal, thus giving it extra thickness just sufficient to counteract the pressure of the lathe centers and of the tool.

Having at last gotten the crank into the lathe, the rest is easy. Anybody can do the trick now, and as one man said to the writer when he was putting a complicated shape into the lathe: "When you get that thing ready, I'll come in and run it for you." It is well to use the water cut in finishing the wrist-pins, as it is hard to make a good job at filing them for the good reason that they cannot be run fast enough for a good filing speed because of being badly out of balance. Of course, they can be temporarily balanced, but filing is a make-shift method of finishing at best, and it is a great deal better to use the water finish and secure a first-class job to begin with.

CHAPTER XIV.

MILLING IN THE LATHE.

In regard to a milling attachment for the lathe: while such a fixture is a great convenience, the smith should look the matter over very thoroughly indeed before spending any money or time on such an attachment. The gist of the whole matter is just this: If you ever intend to enlarge the earning capacity of your shop, then do not make a milling attachment for the lathe. If you are satisfied to do just what work can be handled by one man, then the milling and any other attachments and jigs are in order, for they are great conveniences but are not money makers. This may be a surprising statement to many a smith, but look again and see if it is not the truth.

The writer has a friend who is a crank on the subject of lathes and attachments thereto. He has a very fine lathe and over thirty attachments for milling, drilling, shaping, planing, gear cutting and about every other operation known to the machinist. And what is the result? The earning capacity of that lathe is only about one-half that of an ordinary screw-cutting lathe. Why? Because the machine is idle so much of the time while attachments are being applied, adjusted and removed.

The only things in common to all operations in that lathe are the bed, the spindle, the head-stocks and the slide-rest—and sometimes, to a limited extent, the feed. And in addition, and most important of all—if there is one—the cross-feed on the slide-rest of the lathe. Even with the above mentioned very few common properties there are lots of times when it is found that the form of bed or centers, or bed or spindles, are most illy adapted for the work to be done and to overcome this difficulty attachments have to be designed which cost almost as much, if not quite, as would a special machine to do the work of that attachment.

Right here is the keynote of success in machine work, blacksmithing or any other mechanical operation. It is this: Do not mix your machines. Put in one machine for outside turning, another for inside work and rig up an entirely different

machine for milling and another for each kind of special work which comes along. Let the lathe be earning money for you in its own way. Do not cut down its profit-producing capacity by stopping it half the time to turn it into a very poor substitute for some other machine.

But, says the one-horse man: "The lathe is there, it is idle now, so why not use it for milling and save the expense of another machine?" It can be done, and the writer will tell how to do it. But while rigging up that lathe for milling and spending time and money on it just remember that you are retarding the expansion of your business and putting into the hands of your competitor the chance to get ahead of you. "What should be done?" Make an attachment which will stand on its own legs instead of on those of the lathe, that's what should be done—and the writer proposes to tell how to do that also, in order that the man who wants to make the most money may be prepared to do so. A special machine for fluting taps and reamers will cost hardly more than an attachment for doing that work in the lathe —and then you have the labor and profit from two machines instead of from one. "Savez?"

APPARATUS NECESSARY.

In order to do small jobs of milling in the lathe the following things are necessary: an arbor or other support for the milling cutter; means for revolving the cutter strongly and at any desired speed; means for holding the work, preferably between centers; means for revolving and locking the work at any desired part of a revolution, in order to provide as many flutes as are required; a vise or clamp arrangement in place of the revolving centers when the character of the work requires it; a table for supporting the centers or vise or clamps; means for moving or feeding the table evenly, accurately and strongly in any direction, forward or back, laterally or up and down—such feeding to be automatic and variable in speed.

Let's now look the lathe over and see what is present and what is lacking from the list of "means." The milling cutter should always be purchased ready made. It does not pay to make them at home. While one can be made at home for $1.20, another "just like it, only better," can be purchased for 30 cents. The support for the cutter—the mandrel or arbor—can be made

at home and must fit the lathe. Details for this will be given later. To support and rotate the cutter of course the spindles of the lathe will be used. So far all is well, but now trouble commences. It is evident that the slide-rest must be made use of to support the work and carry either the centers or the vise or clamp used for holding the work. The fact that there is only a space of a few inches between slide-rest and lathe centers is a most discouraging fact, but it can't be altered or obviated. That is one of the "must" things and we "must" make the best of it. Thus the range of work which can be milled in the lathe is at once limited to one-half the swing of the lathe, less half the diameter of the milling cutter, less the thickness of the sliding table and the center raising device. Thus only very small work can be milled in the lathe.

The length of milling cut is also very limited, and in a 20-inch lathe it is hard to provide for milling a cut over 10 inches long, while the diameter of the possible work, as limited above, can hardly exceed 3 inches, however economically the device may be arranged as regards vertical space.

DIVIDING HEAD.

In order to properly space the milling cuts around the periphery of a tap or a reamer the milling attachment must be fitted either with an index plate or a dividing head. The former takes up a lot of room but could be placed at the back of the lathe and could be made fairly accurate in the shop. The dividing head usually consists of a worm wheel and screw which is actuated by means of change gears in such a manner that any desired part of a revolution may be given to the work by merely turning a crank a certain number of times for each cut. Both the index-plate and the dividing head are to be attached to the live spindle which supports one end of the piece to be milled.

A rudimentary dividing head is quite within the make of the smith, but the index-plate is much quicker made, though not as convenient as the dividing head, which can be made with considerable accuracy provided the worm wheel is accurately spaced. It is understood that the centers and the vise or clamp for holding work are never used at the same time, and that the dividing head or plate is used only with the centers, or with the work chucked on the spindle of the head or plate, therefore it is nec-

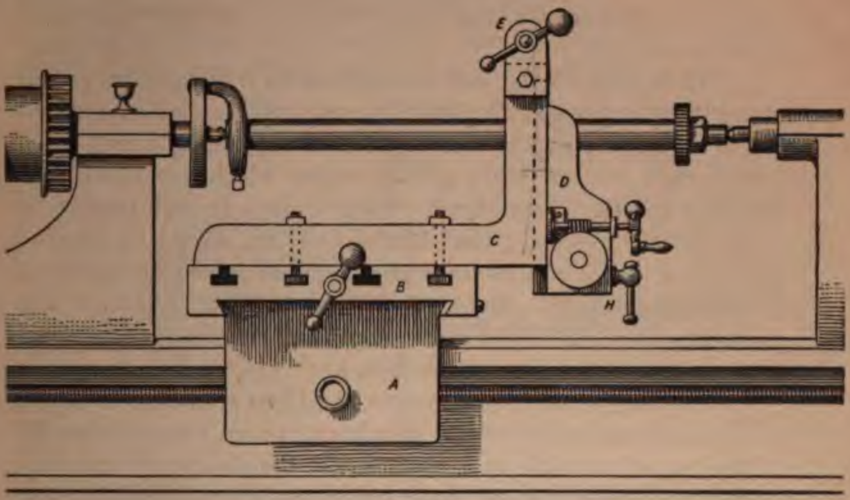
essary that the table of the attachment be made to receive either of the above-described articles. This table must also be made to be raised or lowered at will, in order to obtain the required depth of cut from the milling cutter which hangs between the lathe centers above the table.

It is in the means for raising and lowering and locking this table that the lathe milling rig becomes a complicated and cumbersome affair. In order to obtain any range of movement worth considering the means for vertical adjustment must be removed from the space between the lathe spindle and the V-ways. This means that the raising and lowering mechanism must be placed outside the bed of the lathe and made in two parts, one at the front, the other part at the back of the lathe. Each part of the attachment could be raised or lowered either simultaneously or separately, and by connecting the two by means of a flat plate work of almost any description could be readily held upon the plate mentioned or clamped in the vise fastened to the plate in question.

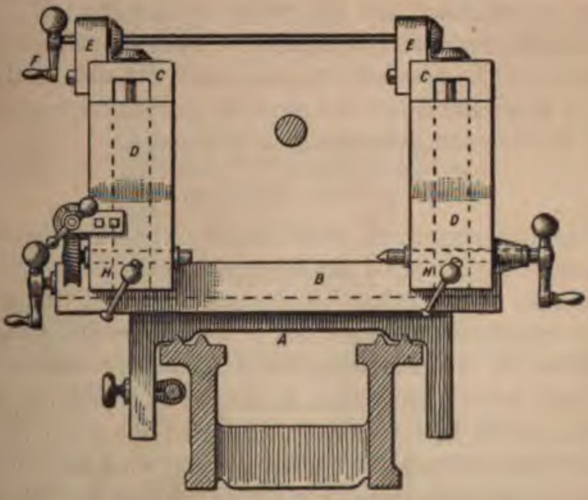
While it is quite possible to arrange a little milling attachment to be fastened to the slide-rest which will handle taps and dies, it seems folly while an attachment is being made for milling in the lathe not to give said attachment as much range for work as possible. To this end do not use the slide-rest at all, but make a special casting to slide upon the lathe Vs, and upon this casting place all the adjusting mechanism necessary. Then, in order to change the lathe to a milling machine, it will only be necessary to raise the tail-stock of the lathe by means of the chain differential blocks, which should be suspended permanently above any lathe, run the slide-rest down toward the tail end of the lathe, past the tail-stock, which is then replaced on the Vs. Next, swing the milling attachment into place between head and tail-stocks and the lathe is a milling machine.

MILLING SLIDE REST.

Fig. 75 gives an idea of this arrangement, at least it attempts to show what the special castings look like and how the several adjustments are made. The main casting A (similar figures or letters indicate the same pieces in all the views of a figure) is planned to fit the lathe ways the same as a slide-rest. In fact, it is one, and is gibbed down and attached to the



Side View.



End View.
Fig. 75—Milling Attachment for the Lathe

feed rod or screw precisely the same as the slide-rest. The casting B is the main table of the milling rig and is gibbed to casting A and fitted with a feed screw which should be attached to power as a cross feed, which may be worked by hand if necessary.

The forcing of the tool into the cut in horizontal milling is done by this screw. The table B may best be slotted for bolt heads as shown, and to it are fastened two strong knees, C C, which each in turn carry gibbed stocks which are fitted with spindles for the reception of center work. It will readily be seen that the sliding, gibbed blocks D D are raised or lowered by screws, which in turn are geared together so as to be operated by a single crank F. The blocks C C and D D may be moved at will along the table B and made fast at any desired distance apart within the limit of the table length.

Referring to the side elevation, it will be seen that the knees C C permit the work-holding spindles to be set either above the table B or at one side of it as shown in the side view, thus permitting a great range of work and obviating to a considerable extent the handicap of the small distance between the lathe Vs and the lathe center. By means of the overhang thus secured the entire distance from lathe bed to center is available, and in many instances larger work can be handled, for the reason that it can project down into the cavity in the lathe bed.

The details of this attachment are not shown, for the reason that it would be necessary to work them out differently for each type of lathe, and it is a fine piece of educational business for the smith to work out these things for himself.

ANCIENT INDEX PLATE.

Fig. 76 represents quite crudely the time-honored index plate, which is a disc of any convenient diameter attached to the live spindle of the milling attachment. Holes dividing the circle into as many—or into multiples of as many—cuts as are desired are drilled in circles through the plate, and a pointer is rigged to drop into one of these holes at a time and hold the plate rigid while a cut is being made. Sometimes the plate is stationary and the pointer is attached to an elongation of the spindle, which passes, in this case, through the plate. When a different spacing is required the pointer is shifted to another circle of holes which

contains the number of holes either straight or in multiple of the number of cuts required around the circumference of the work.

MODERN DIVIDING HEAD.

Fig. 77 shows the principle of the more modern dividing head. To the end of the spindle is attached a worm wheel with

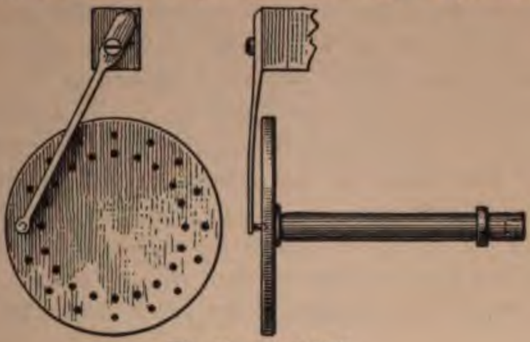


Fig. 76—Index Plate.

a convenient number of teeth. To the block carrying the worm which engages this gear is attached a graduated circle around which sweeps a pointer attached to the worm shaft. Almost any number of divisions can be given to the circumference of a

Fig. 77—Dividing Head.

piece of work by turning the worm shaft a given number of revolutions and parts of a revolution, as indicated by the graduated circle noted above.

In some more elaborate dividing heads there are change gears to drive the worm shaft, so that almost any combination of partial revolutions can be made by complete turns of the crank, without having to use the graduated circle at all. Means must be

provided for clamping the spindle after setting, similar to that shown at H, before each cut is made, as the pointer in the index plate or the friction of the worm in the gear is not designed to lock the spindle for a cut. An independent clamp should be provided in each instance, and the clamp must be loosened after each cut before the work is rotated for another cut.

It is understood that when the center spindles shown in the side view of Fig. 75 are not needed that they may be quickly removed and a pair of vises or clamps applied to the knees C C in the place of the centers and spindles. Or by a slight change in the design the spindles may be pulled out and the castings D D turned into vise clamps by the addition of another bit of metal and a screw to each casting. In fact, the face of each of these clamps may be readily fashioned into vises to remain permanently in place for use when wanted, with no change whatever, except to remove the spindles if the latter chance to be in the way.

After you have made up this attachment and have gotten it to working satisfactorily, then buy an old lathe bed and put the attachment upon it, thereby leaving your lathe free for its legitimate duties.

CHAPTER XV.

SPECIALIZING VS. GENERALIZING.

In most trades, and in some branches of blacksmithing, the tendency is toward very narrow specialization. In fact, toward doing only one thing. Thus, the smith sometimes finds it profitable to do nothing but shoe horses, while another man repairs vehicles exclusively and shoes no horses nor does any repair work whatever. Still another man confines himself to repair work exclusively. But the tendency of smithing is to generalize, to add repair and manufacturing branches; in fact, to become a regular "department store" in the mechanical line where can be obtained almost anything desired in the iron or woodworking lines. To this end the smith is fast invading the field heretofore occupied by the machinist, and he has always been a sort of woodworker when occasion demanded.

A certain branch of smith work known as "machine blacksmithing" has heretofore been an unknown art to the average smith, and this branch has been very closely allied to machine work. In fact, a "machinist" (not a specialist in that line, lathe hand, vise man, fitter, etc.) is usually a pretty good blacksmith, well up in tool making and general forging, although he knows little about carriage work and nothing about shoeing.

The smith who desires to progress should work into machine blacksmithing as well as into lathe work. And both these branches require the same study and preparation. A man may be a good smith if he cannot even read and write, but he will be a much better one, and earn better wages, if he can make and read sketches and drawings. To that end let the smith learn to draw, also to make simple patterns for castings.

MAKING DRAWINGS.

Many people have an entirely incorrect idea of the making of drawings. Some of the schools seem to teach that when a pupil can copy a drawing and make nice smooth lines that the pupil knows how to make machine drawings. But nothing could be

further from the truth. In fact, two things are necessary for the draftsman (or the smith who would make sketches) to know: First, how to put lines on paper which will show the desired object in such a manner that a smith can make it with no other guide or instructions than the drawing in question. Second, the smith-draftsman must know how to proportion the object so that it will possess the necessary strength with the use of the least possible material and at the same time be of such proportion and finish as to present a pleasing appearance.

The man who can make a picture of a bolt or a nut may not be able to name the proper dimensions for those objects, and, on the other hand, the smith who knows how to make properly proportioned bolts and nuts may be unable to express his ideas on paper in the shape of a drawing or other sketch. In the former case a good deal of study will be necessary; the strength of materials must be mastered and the laws of machine design must be studied. In the latter instance a very little study will fit the smith to make intelligent drawings from which any man who can read drawings can work easily and correctly. Two very simple examples will illustrate this point:

DESIGNING AN EYEBOLT.

When a lathe is to be set up in your shop it proves very handy to rig an eye-bolt in a beam overhead. By means of a rope tackle the lathe is lifted from the wagon and deposited upon rollers placed on the floor of the shop. The lathe weighs 4,200 pounds. A three-ton tackle is used, weight 200 pounds, giving a six to one purchase on the lathe. How thick should the eye-bolt be made to be safe to carry the load, yet not too large, which would add to the cost of the bolt?

The lathe load is 4,200 pounds. The tackle weighs 200 pounds, and with a six to one tackle, 700 pounds pull would be necessary to balance the 4,200 pound load to be lifted. Something must be added for friction, and 800 pounds may be taken as the pull. This necessitates nine or ten men on the rope, and as they may put 1,000 pounds on the rope should it become tangled, then the eye-bolt should be made strong enough to withstand a pull of 4,200 + 200 + 1,000, or 5,400 pounds.

The tensile strength of bar iron (soft steel) may be taken at 60,000 pounds to the square inch; that is, it will require a pull of

60,000 pounds to break a rod one inch square. To withstand a pull of 5,400 pounds there will be necessary about .111 square inch section of metal. But it must be remembered that .111 square inch of metal will barely sustain a pull of 5,400 pounds. In fact, it is expected to break under that pull, hence more metal must be added until there is no doubt that the rod will sustain the load under any conditions likely to arise. These conditions must include possible poor quality of metal, defective forging of the eye-bolt, defective thread, and perhaps a poor nut.

FACTOR OF SAFETY.

The excess of strength which must be thus provided is known as the "factor of safety." It varies according to the work to be done. In unimportant places the factor is sometimes as low as 2. That is, twice the metal that would be broken by the given load is allowed. In the case given above, where .111 square inch of metal section is required .222 square inch would be used. But a factor of safety of 2 is entirely too small. In steam boilers 4½ and 5 are the factors of safety usually employed. In bridge work and in locomotive construction 10 is used as a factor of safety, and this factor is used in all machine design where metal may be subjected to shocks and other sudden strains.

For the eye-bolt which we are designing a factor of 5 should be used, which will bring the metal section up to $5 \times .111 = .555$ square inch. The next problem of the smith designer is to find what diameter of round rod will have a cross section of .555 square inch. To ascertain this point it is necessary to divide .555 by .7854 and extract the square root of the quotient. This gives a diameter of .84 inch. This corresponds closely to a rod ⅞ inch in diameter, which should be used for making the eye-bolt.

Having ascertained the diameter of metal required for the eye-bolt the rest is easy. The length is obtained from the conditions to be complied with in using the bolt. If it is to pass through a 6-inch beam, then a total length of 11 inches, as shown by Fig. 78 will answer. Of this length 3 inches may be taken up by the eye, 2 inches by the threaded portion, including the nut, leaving 6 inches to pass through the beam.

The smith will readily see that the making of the picture or sketch as shown by Fig. 78 is a very small matter. Once the

diameter of the rod and the length of the bolt are determined the design of the eye-bolt is complete and it only remains to make the picture in such a manner that any smith will be able to make the bolt without any instructions whatever except those found upon Fig. 78. It is understood, of course, that the thread is to be U. S.

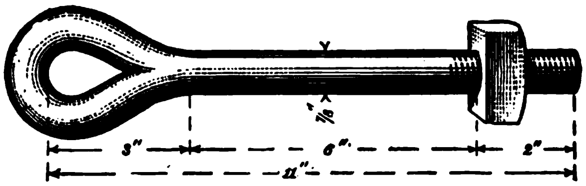


Fig. 78—Designing an Eyebolt. "Expansive" Blacksmithing.

standard, which is 9 to the inch for ⅞-inch bolts, hence no instruction is needed in that direction. The sketch also shows a square nut but no washer, therefore the smith needs no instruction in that direction. The eye is shown to be a long concern, therefore the smith need not spend time in rounding it up around a punch. If a round eye were necessary it would be shown thus upon the sketch. In fact, as stated, every bit of information needed for making the eye-bolt is to be found in the drawing.

DESIGNING A CASTING.

The same is true in making a design for a casting or for a bit of lathe work. First determine the dimensions of the object by the necessary calculations, then make the sketch or drawing to show everything the workman needs to know. If a mechanic has occasion to run after the draftsman and ask questions, there is something wrong. Either the drawing is incomplete or the workman does not know how to read it properly.

For example, assume that the smith wants a pair of brackets to bolt against a brick wall. A shaft must be hung there and the brackets are to be arranged to receive each a rigid flat box or pillow block, something as shown by Fig. 79. The bracket is also shown by three views—plan, end and side elevations—Fig. 80 The writer will not give here the work actually done in designing this bracket, but will give some of the necessary data and leave it for the "expansive blacksmith" to work out the details for himself. Let it be stated that the center of the shaft is to be placed 24 inches from the brick wall and that each bracket shall be safe

(factor of safety of 5) to carry 3,000 pounds vertical load at that point.

The problem for the designer is, therefore, to determine the length, breadth and thickness of the vertical and level portions of

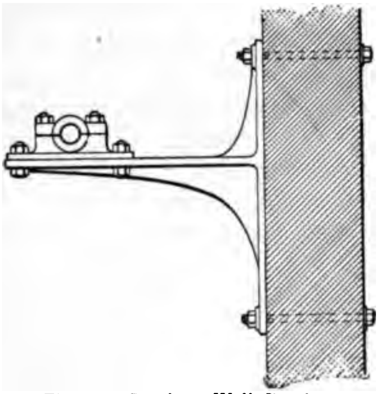


Fig. 79—Cast-iron Wall Bracket.

the bracket. There will be four ½-inch bolts for fastening the box to the bracket. But the size of the two bolts which fasten the bracket to the wall must be calculated. When cast iron is sub-

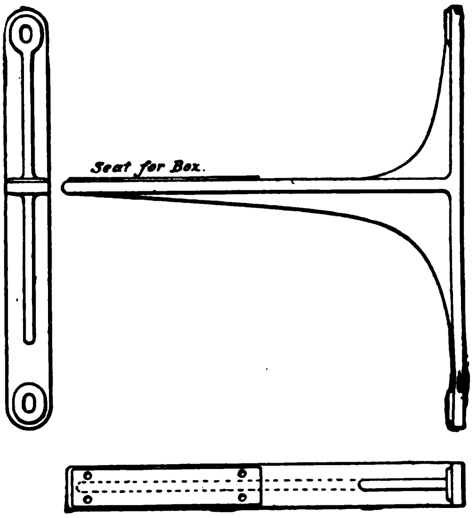


Fig. 80—Bracket Separated from the Wall and Box.

jected to a pull it is under tensile strain, and not over 26,000 pounds to the square inch should be permitted. When cast iron

comes under compression strains, then a much greater figure is permitted.

REFERENCE BOOKS.

At this stage of the game it is up to the smith to obtain one or two good reference books in mechanical engineering. To properly design the bracket noted above the smith must have complete data of the strength of materials, the moment of inertia, the strength of beams and other data. For this purpose a book like Kent's "Engineer's Pocket Book" is necessary. There are several good books of similar character on the market, and doubtless the publishers of this book will procure for any reader, upon request, a suitable reference book for the purpose. The smith must have at least one book of this kind, and he will find frequent use for it right at the beginning. As the "expansive" work progresses the smith will find use for two or three books of similar character, though in a slightly different field. Trautwine's "Engineer's Pocket Book" will answer all questions which may arise concerning building problems. It tells all about geometry problems, and covers all work the smith will ever get up against in building a shop, tinning the roof, calculating foundations, drawing, building railroad switches or anything of that kind. Add to the above books, later, perhaps, one or more good books on electrical engineering and the smith will be ready to "meet all comers."

The smith, by the addition of a screw cutting lathe to his shop tool equipment, has found that he must at once learn three or four trades additional to that of blacksmith. Instead of remaining a mere shoer of horses and maker of wagons he must expand into a machine blacksmith, a pattern maker, an iron founder (molder) and a machinist. As far as concerns the machine blacksmithing and the lathe work, the smith can be trusted to make his way with little trouble.

PATTERN WORK AND MOLDING.

It is in the lines of pattern making and molding that the smith needs aid and instruction. In pattern making that he may be able to fashion correct patterns for such castings as he may need to keep his lathe work agoing, and in molding that he may be able to properly design and arrange such patterns so as to get good castings from them. Cast iron is a very peculiar material to

handle and the design has much to do with the soundness of the castings also with the cost or waste of iron in the castings in question.

It is possible—yes, quite easy—to put twice the necessary metal into a casting and still have it prove too weak for the purpose intended. It is, then, necessary for the smith to study the behavior of cast iron in order to know how best to distribute the metal. Certain shapes and proportions are also necessary in order to make the molten metal form into a solid casting when cooled. If certain proportions are not followed the castings will crack or break to pieces through internal strains.

Certain other shapes and proportions must be given to every pattern in order that it may be properly removed from the sand during the operation of molding. Fig. 81 shows this matter

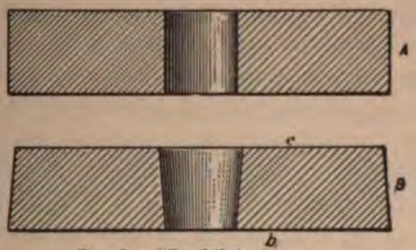


Fig. 81—"Draft" in Patterns.

plainly. The novice in pattern making who needs a cast iron circle with a round hole through its center will probably turn out a pattern with a section like that shown at A. The circular portions of both pattern and hole are made square with the flat faces of the pattern, and the molder will have no end of trouble in getting the pattern out of the sand. The outside of the pattern will cling to the sand and probably it will shear off the top corner of the mold when the last corner of the pattern leaves the mold.

"DRAFT" IN PATTERNS.

That portion of the mold which forms the "core," or which is contained in the hole in the pattern, will also give trouble. The molder puts two or three nails in the sand packed into the hole in question, but even then the pattern will be almost sure to tear off the top corner of the sand and make necessary a tedious patching and building up of the mold after the pattern has been taken

out. To obviate this difficulty and remove the trouble entirely it is only neccessary to taper the pattern as shown at B, Fig. 81 Then, in molding, the pattern is so placed that the larger flat side will be on top, the smaller side C at the bottom of the mold.

Always, before commencing to "draw" a pattern the molder will thrust a screw or a sharp pointed rod into the pattern and strike sidewise on the rod, just above the pattern, several smart but light blows with a small bit of metal—a spike or a bit of rod. This causes the pattern to free itself from the sand. The molders call this action "rapping" the pattern and it should be done cautiously and with a good deal of care, otherwise the mold will be made too large by excessive rapping and the truth of the casting seriously affected.

When large patterns are made it is customary to add one-eighth inch to each foot of every dimension. This quantity is called the "shrink" of a pattern or a casting and it just makes up for the amount which the casting "shrinks" or contracts during the act of cooling. In making very small patterns no "shrink" is allowed, for the reason that the rapping of a pattern usually enlarges the mold just about enough to make up for the "shrink" of the casting.

The taper which should be given to a pattern—the "draft," as it is called in the foundry—need only be very slight. One-sixteenth of an inch on each side of a pattern will allow one-eighth of a inch clearance when the lower edge of the pattern comes to the top of the mold, and this amount of "draft" will make it easy to get a pretty large pattern out of the sand without trouble. And here comes up another nice point in making patterns. It is usual to so arrange the draft on a pattern that the side which is of the most importance shall be at the bottom of the mold when the iron is poured in. The bottom of a casting is always the best side and is the most free from blow holes, slag or other imperfections with which castings may be afflicted.

CASTINGS BROKEN BY POOR DESIGNING.

As regards the cracking or breaking of castings through poor design, this matter is graphically shown by Figs. 82 and 83. In Fig. 82 the casting is for a grate, but the principle is the same as for a pulley or a gear. When a pattern is made with a heavy circular ring connected at intervals by bars, or continually by a

web or disc, it is very certain that the casting will come out of the sand broken in one or more places. Fig. 83 aids in understanding why such breakage occurs. The heavy circular rim holds the heat

Fig. 82—The Casting that Broke Because of Faulty Design.

much longer than the small bars comprising the lattice work of the grate, so that the rim is still hot after the grate has cooled. Then, when the ring cools, the grate portion is crushed and is forced up into a more or less conical shape until the bars break or until the cooling strains are equalized. Should the grate be made thick and the outside ring thin, then the ring would cool first and the slow cooling bars would pull themselves in two during the

Fig. 83—Section of a Casting That Broke.

strain adjustment. It is for this reason that castings must be so proportioned that cooling strains will not distort them.

The study of an engineering handbook will enable the smith to properly design a casting that the strains may be properly distributed. This is important to the smith because it is quite possible for many a smith to set up a small cupola and melt iron and make the casting required. This is another "expansive" method by which the smith can increase his cash account when there is not a foundry near at hand.

CHAPTER XVI.

SPEEDING A CIRCULAR SAW.

It frequently happens that the power-using smith finds himself "up against it" when a new machine is to be put into the shop. Perhaps the lathe and drill press are working profitably and it is found necessary to put in a circular saw. Such a tool will require power enough to drive half a dozen lathes and the speed of the saw is so much faster than is required at a screw-cutting lathe that serious complications arise in obtaining sufficient power to drive the machines and to get the proper speeds when the necessary power is to be had. If a circular saw is to be set up its speed must first be determined. The "rule of thumb" for speeding a circular saw is to run it a mile a minute. That is, the periphery of the saw (the toothed circumference) should travel at about 5,280 linear feet to the minute. If a 10-inch saw is to be used the speed of the saw arbor should be about 1,960 revolutions to the minute. If it is to be a 20-inch saw, then 980 revolutions will be enough to give the same tooth velocity.

According to the above rule, a 6-inch saw should make 3,350 turns to the minute, while a 36-inch saw should run only about 540 turns, while a 48-inch log saw should trundle along to the tune of only about 400 revolutions to the minute. But the smith will get into difficulty at the start. The saw bench he is intending to set up is fitted with saws ranging from 6 to 18 inches in diameter, and evidently the speed which will be right for one size of saw will be wrong for some of the other sizes. It is for the above reason that some saw arbors are made with a stepped pulley to receive the driving belt, in order that the small saws may be driven at greater speed than the larger saws, thereby approximating the correct speed for each size of saw—a rough approximation, to be sure.

While the 6-inch saw should run 3,350 revolutions, the 18-inch saw should be speeded at only 1,110 revolutions. In a case like this it is well to under-speed the small saw considerably and over-speed the large saw only slightly, giving the saw mandrel a speed of say 1,660 revolutions in order to obtain the best average results. At 1,660 revolutions a 12-inch saw would have the proper speed and all other sizes would run either too fast or too slow, according to their diameter. It is probable that saws about 12 inches in diameter would be used more than any other size, hence that speed is the nearest right.

If it should be desired to speed up the mandrel for a smaller saw the speed would be too great for the large saw, its rim would stretch under the tremendous centrifugal force and the saw would "wander" around from side to side, instead of standing up stiffly and cutting a straight kerf. If it is found necessary to speed up for a small saw the larger saws may be hammered for the high speed at which they run all right after the center of the saw had been stretched by hammering, but saws thus hammered would not run well at a slower speed than they were hammered for.

Having thus found that it may be necessary for the smith to change the speed of some or of all the shafting in the shop when another machine is to be put in, it will be in order for the smith to provide pulleys which will give the proper speed to shaft or to machine. It may be found necessary to provide a pulley 48-inch diameter, 8-inch face, to fit a 2 7-16-inch shaft. Such a pulley may be found at the nearest machinery depot or hardware store. If so, buy it by all means. Probably a wooden pulley will answer all requirements and its cost will be only about one-half that of a cast-iron pulley. Sometimes wrought steel split pulleys are obtainable. These are very desirable pulleys and give excellent service.

MAKING A PULLEY.

But perhaps there is no pulley in the store. More frequently there is no store, and the smith must hie himself to some more or less distant foundry which happens to have a pulley pattern of the required dimensions. But there is a way by which the smith with a lathe can get up a fine pulley even cheaper than the price of a wooden one. Let him make up a pattern of a flanged hub,

something as shown by Fig. 84. This pattern may be turned up in the screw-cutting lathe. It is more fully shown by the sectional view in Fig. 85.

To make this pattern drawings are first gotten out and the several dimensions determined as a matter of course. The pulley is to consist of several layers of dressed lumber, each layer with the grain crossed against the adjacent layers, and glued and nailed firmly together. The thickness of the web thus made to be about 3½ inches, and consisting of four thicknesses of ⅞-inch stuff. The remainder of the pulley face to be formed of six layers, three on each side, of ⅞-inch segments, nailed and glued in place as shown by Fig. 86.

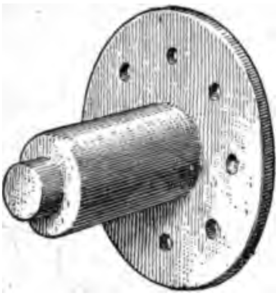


Fig. 84—Flanged Pulley Hub.

The diameter of the cast-iron hub is determined by the diameter of the shaft on which the pulley is to be placed. In this case it is 2 7-16 inches, therefore the hub must be large enough to bore that diameter and still possess sufficient metal to stand the strains of work. In this case another matter determines the thickness of the "wall" of the hub, as the section outside the

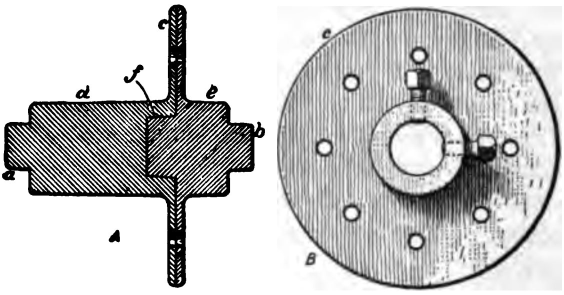


Fig. 85—Sectional and Side View Flanged Pulley Hub.

bore is called. The diameter of set screw is the determining factor. As the pulley is to be 48 inches in diameter and must carry an 8-inch belt there will be exerted to shear off the set screws a power of 8 x 40=320 pounds; the pull of the belt, exerted through a leverage of 24 inches, against another leverage of about 1¼ inches (half the diameter of the shaft), about 19.2:

320 x 19.2 equals about 6,150, slide rule calculation, and allowing a factor of safety of 5, about 30,700 pounds of shearing strain for the set screws to hold. It is never well to subject set screws to more than 45,000 pounds to the inch strain in single shear, as set screws are exposed, therefore it will require 30,700 divided by 45,000, or 0.685 square inch of set screw section.

SIZE OF SET SCREWS.

A ⅝-inch set screw is about ½-inch in diameter at the bottom of the threads (0.507) and its sectional area is about 0.2 square inch. To obtain a total area of 0.685 divided by 0.2, which equals 3.42, showing that more than three ⅝-inch set screws are needed, therefore four must be put in. As ⅝-inch screws are to be used the wall of the hub need only be thick enough to serve as a nut for the screws, the thickness of wall needs be equal to the diameter of the screw, or ⅝-inch. Thus twice ⅝-inch added to 2½ inches, gives 3¾ inches as the neces-

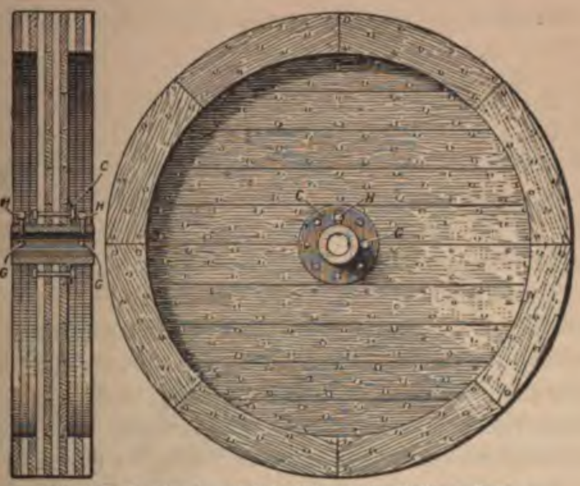


Fig. 86—Sectional and Side Views of a Built-up Pulley.

sary thickness of the hub. As it is desirable to get rid of fractional measurements when just as well without them the draftsman would call the hub 4 inches in diameter. In all designing,

care should be taken to keep to even dimensions, and it can usually be done without increasing the cost.

The length of the hub should be such as will permit the set screws H, H, and G, G, of the sectional view in Fig. 85, to be placed outside of the solid web of the pulley. The smith can determine this dimension for himself. The flange, C, is next to be figured and dimensions obtained for it. Here is a piece of metal which must stand the strain of several bolts in single shear the same as set screws, only the bolts being further from the center of the shaft the leverage is reduced. The bolts must be placed far enough away that the nuts can be turned outside of the hub, say 2 inches away therefrom, making the total distance about 4 inches from the center of shaft. Therefore the leverage for these bolts will be 24 divided by 4, or 6. The strain on the bolts will therefore be 320 x 6 or 1,920 pounds, and with a factor of safety of 5 the strain amounts to only about 9,600 pounds, against 30,-700 pounds which the set screws had to withstand. It will be seen that the bolts can be quite small, but they should not be made less than 7-16-inch or ½-inch on account of the danger of twisting them off when screwing up the bolts to tighten the wooden web of the pulley.

THICKNESS OF FLANGE.

For the same reason the thickness of the flange should not be made less than ½-inch, for fear that it be broken by setting up some of the bolts while the wooden web does not bear fair upon the flange, thereby setting up strains foreign to the work the flange is designed for. The total diameter of the flange needs to be considerable in order to secure a good bearing of the web against the iron and make the pulley run true. A distance outside of the bolts equal to the distance from bolts to hub would appear to be about right. This brings the bolt circle 8 inches in diameter and the flange 12 inches in diameter, making what appears to be a well-proportioned design.

The smith now has the design of the hub all figured out and it is an easy matter to lay it down on paper. The next thing is to proceed with the pattern, which should be made of well-seasoned white pine or mahogany. Bay wood is used a great deal for patterns, and they are charged for as made of mahogany. Never try white wood for patterns. It will not work well if to

be used after being kept for a while. Patterns made from white wood will twist out of shape and become useless.

SPLIT PATTERN—CORED HOLES.

This pattern may be molded if made all in one piece, but it will work much better if made in two pieces. It had best be divided cross wise as shown at A, Fig. 85. By dividing in the middle of the flange all the bolt holes may be made by green sand cores, whereas if the pattern be divided longitudinally, through *a*, *b*, sketch A, Fig. 85, the holes in the flange must be drilled, as they cannot be cored when the hub is thus divided.

In practice, the piece *d* should be turned up, making the recess at *f* to receive a corresponding projection on piece *c*. The holes in the flange are then made tapering as shown in both views, and two projections are left, one at either end of the hub, as shown by *a* and *b*. These projections are called "core prints" and are made the same diameter as the hole desired through the hub. As the hole must be cored to 2 7-16-inch, some metal must be left for machining, therefore a core about 2 inches in diameter should be provided for, which means that the core should be of the same diameter as the prints and of a length equal to the distance from end to end of prints *a* and *b*.

For special cores it is necessary to make a "core box," in which the cores will be made, but for round cores no box is necessary, as every foundry is supplied with these boxes and keeps round cores of all sizes made up in advance, which may be cut off to the required length when wanted.

CORNERS ON PATTERNS.

In making the drawing for this casting, and for any other casting, the smith should always avoid as far as possible a square corner where two surfaces come together. Note in the sketches, particularly at A, Fig. 85, the connection between the hub *d* and flange *c*. There is shown a rounded corner like that at A, Fig. 87. Never permit or show a corner like B, Fig. 87. Such a corner is weak and fosters cooling cracks in the casting which frequently spoil castings containing them. Whenever two surfaces intersect in a casting see that the junction is nicely curved with as long a radius as possible between the two. Always specify on the drawing the radius of any corner. The corner in question is marked for a fillet of 1-6-inch radius.

When two planes are to be joined in a pattern drawing hold up the hand and note the fine curve joining two fingers when they are slightly parted, as is shown in Fig. 88. It is a safe curve

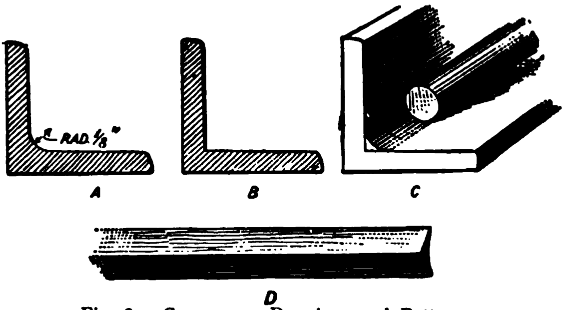


Fig. 87—Corners on Drawings and Patterns.

pattern to follow at all times. In making some patterns it is easier to make the corners square and sharp and fill them afterward to the desired radius. In cases of this kind the corners would be put together square as at B, Fig. 87, and afterward filled with leather, beeswax or putty. The methods are preferable in the order named. A method of filling a corner with beeswax and a hot iron rod is shown by Fig. 87, at C. The wax is melted in and molded and smoothed with the heated rod, after which the surplus wax is removed. Putty is used in the same manner and set with the same tool, except that, with putty, the tool does not have to be heated for its application to the pattern. The leather fillets, C, Fig. 87, may be purchased by the yard of any desired radius and it is only necessary to wet a piece of leather fillet, apply a little glue and rub the fillet into the corner with the same round tool described above. This tool need not be heated for the leather.

Fig 88—Nature's Design for Fillets.

PAINTING PATTERNS.

In making a pattern where core prints are used it is customary to paint the body of the pattern black, then when there are core prints paint them red, as a guide to the molder in setting the cores.

In making up the pulley the several layers of lumber should

all be gotten out, fitted and marked, then put in a dry house or over a steam boiler until thoroughly hot clear through. The hot glue should be quickly applied and the several layers of wood nailed together. The wood must be hot enough to keep the glue melted while the putting together is being done. After the pulley is finished and has become dry, it should be mounted on a piece of shaft and turned smooth all over.

The shaft with the pulley upon it should then be placed on stiff level strips of iron, and the pulley balanced so it will stay in any position without trying to revolve a heavy side down. If such a thing happens, and it is the rule rather than the exception, drive nails into the light side of the pulley until it will lie in any position without the least tendency to rotate. Sometimes it is necessary to bore holes and insert pieces of iron or lead to bring the pulley to a balance.

BORING THE HUB.

One very important operation has been overlooked—that of boring the hub, but the smith is prepared for that operation once he finds a way of mounting the hub upon the face-plate of the lathe. But that operation is really very simple. All that is necessary is three or four small blocks. Place them between the hub flange and face-plate and bolt the hub in place by means of bolts through the flange. Place the block C (Fig. 46, page 83) close to the bolts and tighten up, adjust and pack under one or more of the blocks until the working face of the flange and the hub both run as true as possible. Then the hub is ready to be bored out with an ordinary tool or to have a chucking drill passed through it—and that finishes the lathe part of the job.

The smith in making the pattern of the hub will give it a little taper or draft in the direction it is to be pulled out of the sand. Thus the smith finds it necessary to think out the manner in which the molder will make up the mold and how the pattern must be drawn out of the sand. The smith must also bear in mind that the best side of any casting will be downward when the iron is poured into the mold, and will govern himself accordingly in giving draft. In this casting the side of flange adjacent to long portion of hub should be the best side, hence the pattern is arranged to be molded with that side of the flange downward when the iron enters the mold.

CHAPTER XVII.

SHAFTS, PULLEYS AND BELTS.

In almost every shop where power has been installed there is to be found one or more belts which are always giving trouble, while the rest of the belting does the work easily and satisfactorily. There is a reason for the failure of every belt, and a close study of the conditions under which the belt is required to give service will surely reveal the cause of the trouble.

Some of the catalogues issued by the builders of power transmission machinery contain tables showing the power to be derived from a belt of given width on a pulley of stated diameter. These tables are usually calculated for a speed of 100 revolutions of the pulley each minute. To find the belt power for any other speed simply divide the given power by 100 and multiply by the given speed, or, which is a little easier, multiply the given power by the speed and cut off the two right-hand figures; the remaining figures will be the power which should be transmitted at the given speed.

The tables referred to usually are based upon a belt pull of 88 pounds to the inch of belt width for double belts and 66 pounds to the inch of width for single belts. It has for some time been the practice of the writer to discard the published tables altogether and calculate the power required separately for each belt. The writer has designed several factories in which there was no such thing as a belt which slipped or failed to do all the work expected from it. The secret or rather the cause of this invariable good service from all the belts was due to one thing: instead of allowing 88 pounds pull to the inch of belt width the writer allows only 40 pounds and this, too, for double belts. As for single belts, they are never considered—all the belts used are double.

WIDTH OF BELTS.

Suppose power is being put into the shop and a ten-horse motor is to be belted. There usually is a wheel on the motor shaft, but sometimes that must be supplied by the purchaser, in

which case he is more at sea than ever as to the proper width of belt to use. Ascertain the speed at which the motor will run and the rest of the calculations are rather easy.

Ten horse-power means 10 × 33,000 pounds lifted one foot high in one minute, or 330,000 foot-pounds. If the motor makes 200 revolutions each minute, then there must be supplied 330,000 ÷ 200, or 1,650 foot-pounds to each revolution of the motor shaft. Assume the diameter of the wheel to be placed on the motor shaft and calculate the width of belt necessary, then if the width thus found be out of proportion it can be changed by increasing or diminishing the diameter of the wheel in question.

First, however, the 1,650 foot-pounds to the revolution may be diminished by dividing it by 40, which will bring the answer directly in terms of inches of belt width. Thus, 1,650 ÷ 40 equals 41¼, which is the product of the pulley circumference in feet into its width in inches. If the given number be divided by 3.141 the resulting quotient of 13.1 will be the product of the pulley diameter in feet and the belt width in inches. Thus, if a 3-foot pulley is used the belt width should be 4.37 inches (slide rule calculations). Or, if an even inch width of belt is desired, the pulley diameter should be 39.1 inches. About 40 inches diameter by 4-inch face would be the proper thing.

Should it be found that the speed imparted to the line shaft would be too great with the 40-inch pulley, it is only necessary to divide 13.1 by the width of the belt, or by the diameter of pulley wanted, in order to settle the matter satisfactorily. Thus: 13.1 ÷ 5 equals 2.62 feet, or 31½ inches. Or, if a 24-inch pulley is wanted, the necessary belt width to carry 10 horse-power will be 13.1 ÷ 2, or 6.55 inches. A 7-inch belt would do the business on a pulley 22½ inches in diameter.

COST OF PULLEYS AND BELTS.

It is an easy matter to carry this scheme of calculation to all the pulleys throughout the shop and thus obtain the best possible form of transmission. But there are two other things to be taken into account when calculating the pulleys for a shop, and those things are: the cost of the pulleys and belts. Large pulleys cost more than small ones, and wide belts are much more costly than narrow ones, and these points must be carefully cal-

culated and compared with each other in order to select the pulleys and belts which will carry the required power with the least outlay for pulleys and belts.

A 40-inch pulley with a 4-inch face may cost $14.10, while at the same rate of cost a 22½-inch pulley with a 7-inch face should cost $7.85. It is the cost of belt which makes the small wide pulley transmission a costly thing. Estimating the average length of a belt to be 25 feet, and the cost of a 4-inch belt to be 80 cents a foot, the cost of a 7-inch belt will be about $1.30 a foot, or $20, and $32.50 for the two belts of 25 feet each in length. This shows that the saving of $6.24 in buying the smaller pulley was offset by an additional expenditure of $12.50 in the cost of the belt, thus saving exactly half, or $6.25, by purchasing the larger diameter pulley with the narrower face and the lesser belt. But there is another factor which has not been taken into account. The belt must run over two pulleys and we have calculated the cost of only one. Should the belt run on a pulley of the same diameter on the driven shaft, then the loss in buying a large diameter pulley would exactly equal the saving in procuring the narrow belt, and it is evident in this case at least that it would make no difference which form of transmission was used.

Thus the length of belt enters twice more into the calculations, for with the large wide pulleys there will be a little more belt length than with the small wide face pulleys, and if the distance between shaft centers be greater or lesser than the equal cost figure, then the saving by using either large pulleys or wide belts would have to be calculated for each shaft distance and pulley diameter.

SLIPPING BELTS.

All other things being equal, the pulley of large diameter should be used for the reason that a belt is much more apt to slip on a small than on a large pulley. The surface in contact between belt and pulley is much greater on pulleys of large diameter than on small ones, hence the slip comes on the smaller pulley every time. There should be a limit to the size of pulleys used in transmitting power, especially a limit as to the smallest diameter which should be used. The writer, in a somewhat extensive practice, has for several years followed strictly the rule never to put a pulley less than sixteen inches in diameter on any shaft

which is to drive another or a machine. Of course this does not apply to pulleys on machines, for these are at "owner's risk," and the maker of the machine is responsible for their behavior. It is a mighty good and safe rule to follow that a pulley should never be used with less diameter than twice the belt width, and better three times. Use this rule and give only forty pounds load to each inch of belt width and you will never have a belt fail to do all that is asked from it.

Small pulleys must be used on some machines, and when such is the case increased adhesion can frequently be obtained when the belt must run at exceedingly high speed by turning shallow grooves or channels in the face of the pulley, the channels being made abou ⅛-inch wide and ½ inch apart. Holes are drilled about two inches from each other along the groove, around the entire circumference of the pulley in each groove. The object of the grooves and holes is to let the air escape which would otherwise be caught between the fast running belt and pulley surface. The arrangement above described has been made the subject of one or more patents and is known as the "pneumatic pulley." Just how much stock to take in this device each user must decide for himself.

There is quite a paradox in the action of pulleys and belts, one man claiming that the more surface contact between pulley and belt the more the belt will pull. Therefore the man who increased the contact to the very limit by carefully polishing the face of the pulley so that the belt might come surely in contact with as much of the iron as possible totally failed in his calculations, for when the pulley failed to drive the belt load, and slipped merrily around, turn after turn, a bystander promptly cured the trouble by taking a bastard file in both hands and ruthlessly spoiling the beautiful surface on that pulley by draw-filing the entire face. Then the belt went right to business and never slipped an inch.

BELT ADHESION.

The "pneumatic" pulley is another contradiction of the theory that the greater the contact between pulley and belt the greater will be the power transmitted. The theory fails here by the fact that cutting away one-fourth the pulley face surface by grooves and holes increases the adhesion of the belt. In view of these

facts it is well to cut out the statement that the power of a belt increases according to the increase of contact between pulleys and belt. Instead just write: "The power of a belt increases with the arc of contact, not with the increase of surface." With this supposition the paradox disappears and nothing but a statement of fact remains. By "arc of contact" is meant the distance the belt laps around the pulley. It seems to make no difference what kind of a surface there is, unless it is so polished that the belt cannot get hold of the pulley surface. This is proven by running a belt on a spur gear used as a pulley. It is found that the gear imparts fully as much power to a belt as if a pulley were used.

BELT SPLICING.

The proper method of joining together the ends of a belt is another very much discussed subject and one which will be in dispute as long as belts are used. The writer is, once for all, and all the time, in favor of a cement splice, thus making the belt an endless one. But where this is done there must be some way of tightening the belt, for it is too much work to take up a belt with a splice in it. Either a "binder" or tightener" must be used or the driven machine must be so that it can be moved forward or back to accommodate the belt. Electric generators and motors are all built thus. When the belt needs tightening it is only necessary to tighten up a screw and the machine slides right back until the belt is sufficiently tight.

Next to the "endless" belt comes the belt with the ends joined by means of "Bristol" belt hooks. This fastening is a thin piece of steel with the edges cut into teeth and turned square with the body of the strip, which is made in lengths of one-fourth to three inches, varying by quarters of an inch, so that pieces enough may be placed end to end to reach across the width of any belt. To apply these fastenings the ends of the belt are cut square, then placed smoothly together on the end of a block of soft wood. It is better to hold the belt ends firmly upon the block by means of a nail or two in each belt end. Select such sizes of fastenings as will reach across the belt to within one-fourth inch of each edge. Put the pulley side of the belt next to the block, then with a small hammer carefully drive the fastenings into the belt, keeping the rows of teeth equidistant from the splice. Drive the fastenings clear down to the belt, then remove from the block, turn the belt

over and place it on a piece of iron, then clinch the small steel teeth, keeping them all pointed toward the joint or splice and not letting any of them bend down in other directions. After the teeth have been all bent down take a heavier hammer and drive the teeth below the surface of the belt, so they will not touch the pulley. Upon the driving down of the points depends the smooth running of the belt.

These fastenings are made in several sizes and weights. The Nos. 10, 11 and 12 used on four-ply, five-ply and six-ply rubber belts respectively, No. 11 being an all-around fastening if no other size is to be provided. These fastenings take up but about one inch of the length of the belt, hence when they are cut out—they never can be used but once—they destroy only one inch of the belt length.

BELT LACINGS.

The next choice to the Bristol belt hook is the time-honored lacing of sheepskin or horsehide, and the Blake belt stud, a small affair made of brass with a T-head on either end of it. Both these studs and the Bristol fastening do not remove any of the belt, hence the joint or splice made with them is the strongest possible. When a belt is punched for lacing some of the material is removed by the punch, therefore the belt is weakened the exact amount of material thus removed, hence small holes should always be made when a belt is to be laced and the necessary strength of lacing provided by punching two rows of holes, one behind the other, thus doubling the amount of very narrow lacing which may be used, without increasing the amount of belt cut away by punching.

And now just a few words in regard to the kind of belt the smith should purchase for use in the shop. There are three kinds of belting, leather, rubber and "impregnated stitched cotton." The latter is known locally as "Gandy," "Rub-oil," "Mount Vernon," and by a dozen other names. This belt was patented by Mr. Gandy and took his name. Since the patents expired numerous manufacturers have given their attention to this kind of belt, with disastrous effects upon the quality of the belts turned out.

QUALITY OF BELTS.

These belts are strong, stand the weather well and can be run in wet places the same as rubber, but the great fault with

them is their tendency to stretch. If used on shafts with a good distance between centers, with a load of only 40 pounds pull to the inch of width, then Gandy belts will run well and give little trouble by stretching. But overload them or use them on pulleys close together and they give a great deal of trouble, need to be continually taken up, and slip upon the least provocation. The writer has equipped many factories with them and will do so whenever it is possible to use the belts at a maximum of 40 pounds pull to the inch. Under other circumstances let these belts severely alone.

Leather belts are the most costly of all if they are properly cut out of the back of the hide or skin. The best belts are known as "short lap" and no piece of leather in one of these belts is more than four and one-half feet long. In belts other than short lap the pieces run up to seven and even eight feet in length. These should be avoided.

Rubber belts are made of cotton duck similar to the "Gandy" but coated with rubber instead of being filled with oil. The great defect of the "rubber" belt is the lack of rubber in its construction. The increased scarcity of rubber leads to substitution of other things, to the great detriment of the belt.

CHAPTER XVIII.

THREADING PIPES IN THE LATHE.

One thing which the smith with a screw-cutting lathe will surely be sooner or later called upon to do is to thread sundry pieces of steam pipe. Indeed, it may have to be done in the course of the regular shop work and it is well to be prepared in advance for anything of this kind.

But before telling how to thread pipes in the lathe it will be well to tell how pipes are dimensioned. When we say "a half-inch pipe" little idea of the actual dimensions of that size of pipe is conveyed to the person unaccustomed to handling or working pipes, for the reason that "half-inch pipe" is not one-half inch in diameter, either inside or outside. The nominal diameter of pipe is given in the dimension "half-inch pipe," not the actual diameter, is always larger than the nominal diameter, especially in the smaller sizes.

Pipe commonly known as "one-half" is actually 0.623 inch in diameter inside and 0.840 inch diameter outside, hence the term "half-inch pipe" is apt to be misleading unless the user happens to be posted in regard to pipe sizes. The following table contains so much valuable information concerning steam, gas and water pipes that it is given in its entirety, instead of being abridged, as was the first thought of the writer:

DIMENSIONS OF STEAM, WATER AND GAS PIPES.

Diameter	Actual			Threads To the Inch	Pitch	Circumference		Transverse Area			Length of Pipe Per Square Foot of Surface		Length Containing One Cubic Foot	Weight Per Foot
Nominal	External	Internal	Thickness			External	Internal	External	Internal	Metal	External	Internal		
.125	.4	.27	.07	27.	.037	1.27	.85	.13	.06	.07	9.44	14.15	.....	.24
.25	.54	.36	.09	18.	.056	1.7	1.14	.23	.1	.12	7.07	10.49	.....	.42
.375	.67	.49	.09	18.	.056	2.12	1.55	.36	.19	.17	5.66	7.73	751.2	.56
.5	.84	.62	.11	14.	.071	2.64	1.96	.55	.3	.25	4.55	6.13	472.4	.84
.75	1.05	.82	.11	14.	.071	3.3	2.59	.87	.53	.33	3.64	4.63	270.	1.11
1.	1.31	1.05	.13	11.5	.087	4.13	3.29	1.36	.86	.49	2.9	3.64	166.9	1.67
1.25	1.66	1.38	.14	11.5	.087	5.21	4.33	2.76	1.5	.67	2.3	2.77	96.2	2.24
1.5	1.9	1.61	.14	11.5	.087	5.97	5.06	2.83	2.04	.8	2.01	2.37	71.7	2.68
2.	2.37	2.07	.15	11.5	.087	7.46	6.49	4.43	3.36	1.07	1.61	1.85	42.9	3.61
2.5	2.87	2.47	.20	8.	.125	9.03	7.75	6.49	4.78	1.71	1.33	1.55	30.1	5.74
3.	3.5	3.07	.22	8.	.125	11.	9.64	9.62	7.39	2.24	1.09	1.24	19.5	7.54
3.5	4.	3.55	.23	8.	.125	12.57	11.15	12.57	9.89	2.68	.95	1.08	14.6	9.
4.	4.5	4.03	.24	8.	.125	14.14	12.65	15.9	12.73	3.17	.85	.95	11.3	10.66
4.5	5.	4.51	.25	8.	.125	15.71	14.16	19.63	15.96	3.67	.76	.85	9.	12.34
5.	5.56	5.04	.26	8.	.125	17.48	15.85	24.31	19.99	4.32	.69	.76	7.2	14.5
6.	6.62	6.06	.28	8.	.125	20.81	19.05	34.47	28.89	5.58	.58	.63	5.	18.76
7.	7.62	7.02	.30	8.	.125	33.95	22.06	45.66	38.74	6.93	.5	.54	3.7	23.27
8.	8.62	7.98	.32	8.	.125	27.1	25.08	58.43	50.04	8.35	.44	.48	2.9	28.18
9.	9.62	8.94	.34	8.	.125	30.24	28.08	72.76	62.73	10.03	.4	.43	2.3	33.7
10.	10.75	10.02	.37	8.	.125	33.77	31.48	90.76	78.84	11.92	.35	.38	1.8	40.06
11.	11.75	11.	.37	8.	.125	36.91	34.56	108.43	95.03	13.4	.32	.35	1.5	45.02
12.	12.75	12.	.37	8.	.125	40.05	37.7	127.68	113.1	14.58	.3	.32	1.3	48.98
13.	14.	13.25	.37	8.	.125	43.98	41.63	153.94	137.89	16.05	.27	.29	1.	53.92
14.	15.	14.25	.37	8.	.125	47.12	44.77	176.71	159.48	17.23	.25	.27	.9	57.89
15.	16.	15.43	.28	8.	.125	50.26	48.48	201.06	187.04	14.02	.24	.25	.8	47.11
16.	17.	16.4	.3	8.	.125	53.4	51.52	226.98	211.24	15.74	.22	.23	.7	52.89
17.	18.	17.32	.34	8.	.125	56.54	54.41	254.46	235.60	18.86	.21	.22	.6	63.32

It will be noted that pipes are invariably larger than their nominal diameters, especially in the smaller sizes. This is very confusing at first to the man who has to do with pipes, but it is something which he soon becomes accustomed to. From the table it will be seen that there is a break in the gradual increase of thickness in pipe, occurring at the 15-inch size; the thickness of the 15-inch, 16-inch and 17-inch being the same as the 6-inch, 7-inch and 8-inch, nearly. However, as the smith will probably have a very limited acquaintance with these sizes of pipes, the discrepancy will not worry him in the least.

SIZE OF PIPES.

The columns in the table which give the length of pipe necessary to contain one square foot of surface are very valuable when calculating pipes for heating purposes. So, too, are the columns giving the length of pipe containing one cubic foot and the column of weights.

It will be noted that pipes are threaded in a peculiar manner and that only five pitches are used. This makes the matter of pipe threading in the lathe a very simple matter, for of the pipes likely to be threaded in the lathe only the sizes taking 11, 5 and 8 threads to the inch are likely to be called for. The smaller pipes are usually threaded with a die, as are some of the larger pipes, but the lathe is very often used for threading pipes of 2 inch and upward in diameter.

Obviously, the first thing to do when a pipe has to be threaded in the lathe is to get the pipe into the lathe in such a manner that it can be cut off, if necessary, and threaded when of the right length. If only a short piece of pipe is to be handled then it may be placed between centers, the tailstock set over for the required taper and the threading proceeded with in the usual manner. But it is ten chances to one that the piece of pipe is longer than can be put between centers, even if it is not fully as long as the lathe bed itself.

SPECIAL PIPE TAIL-CENTERS.

A piece of pipe may best be held to the lathe spindle by catching one end of the pipe in a chuck, the other end being supported by the tail-center or by a steady rest. If a tail-center is to be used on large pipe a special form should be used, something

as shown by Figs. 89 and 90. In Fig. 89, a tail-center is shown which is made in two pieces.

The main portion, D, is fitted to the tail spindle in the usual manner, but instead of being pointed at A the protecting part is

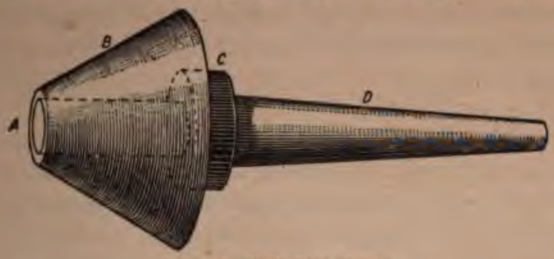


Fig. 89—Shell Pipe Center.

made parallel in the form of a bearing, upon which revolves the center portion of the tool, B. A shoulder, C, takes the thrust of the work and prevents the center, B, from slipping down the shank D, which is, as stated, fitted into the tail spindle. That portion of the center between A and B is lubricated, so that the pipe, instead of turning upon the shell, B, carries that appliance with it and revolves on the lubricated portion instead of in the contact between pipe and shell B. This insures very smooth and steady running, making it unnecessary, as often is the case when a solid center is used, of reaming out the inside corner of the pipe so that it could run true on the center.

When very large pipes are to be threaded another shell center

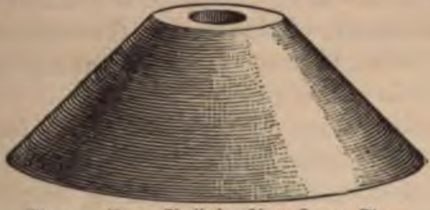


Fig. 90—Extra Shell for Very Large Pipes.

may be provided, as shown by Fig. 90. This fits the same shank as is shown by Fig. 89 and interchanges simply by removing one and slipping the other in place. Both these shells may be made of cast iron or of any material which comes to hand. An old water wheel step furnished material for a shell to accommodate pipes between two and six inches in diameter when the writer happened to be looking for stock for a pipe center. A hole should

be drilled in the dead center, D, Fig. 89, for oil. This hole can be drilled through A, and another hole to meet it drilled through C, the hole in A being plugged at its outer end and one or two other holes drilled to the circumference of A, crosswise through the longitudinal hole, so that oil can find ready access to all parts of the bearing between A and B.

CUTTING OFF AND CHUCKING.

For cutting off steam pipe use an ordinary cutting-off tool, from 1/8 to 1/4 inch wide, according to the thickness of pipe to be cut. When the tool is nearly through the wall of the pipe great care should be taken to prevent the tool from catching in the cut portion of the pipe. If the tool be allowed to catch there is great danger that the pipe will be torn out of the lathe, to the probable damage of the lathe tools and perhaps the lathe itself. When the tool begins to break through the pipe run the belt almost off the pulley, using the belt shipper for that purpose, driving the lathe very lightly, so lightly, in fact, that if the tool breaks through it will slip the belt and stop the lathe, thus preventing the possible breakage of tool or lathe.

Having cut off the pipe to the required length, the next step is to mount the piece to be cut in the lathe in such a manner that the slide-rest can be brought to the portion which is to be threaded. If the pipe is less in length than the bed of the lathe this can easily be done, although with a very long pipe it will be necessary to remove the tail-stock entirely and move the slide-rest down to its place. But when a piece of pipe must be threaded which is longer than the entire lathe, then special rigging must be used, which will be described in a later paragraph.

The face-plate chuck and the steady-rest form about the best mount for a bit of pipe in the lathe, and it will be considered that this form of drive has been applied to the pipe in question and that the steady-rest has been set within two inches of the thread to be cut, say three inches from the end of the pipe. The next step is to taper the pipe as required for the thread. The standard taper of all water, steam and gas pipes is 3/4 inch to the foot.

When the tail-center is used the tail-stock may be set forward to give the desired taper, but this is not possible with the steady-rest, or with a pipe gripped in a face-plate chuck. It is

necessary to turn the taper by the eye, which can be very closely done after a little practice. But the first few times it will be well to use a pair of callipers to get the proper taper. Three-fourths of an inch to the foot means about .0781 inch to a thread 1¼ inches long, or about 5-64 inch taper. As this amount is what the pipe thread should taper in 1¼ inches, it is only necessary to set the callipers to the outside diameter of the pipe, as taken from the table, then screw up the instrument 5-64 inch and turn the end of the pipe to that diameter as given by the callipers. Then it will only be necessary to start a cut 1¼ inches, or less, according to the diameter of the pipe, back from the end, and turn as good a taper as the eye will permit, right down to the diameter already cut on the extreme end of the pipe.

When the end of the pipe is thus prepared it is very easy to cut the thread, as it will only be necessary to turn away at the thread until it becomes full at the very end of the pipe. Then, if the taper has been well made, the thread will have the same inclination, which will be the taper desired to allow the pipe threads to enter each other easily.

CUTTING A TAPER THREAD.

To make the tool cut an even thread along the entire length of the tapered portion of the pipe is the next problem for the smith to solve. Like many other problems, it is a very easy one to solve when the right method is used. Assume that the pitch of the cross-feed screw is eight threads to the inch. Then it is evident that one turn of the screw will advance the tool ⅛ inch. The taper of the pipe thread is about 5-64 inch, or 2½ sixty-fourths on each side of the pipe. This is the amount the thread tool must be advanced in order to cut the taper required. One-eighth inch equals 8-64 inch, the advance of the tool to each turn of the cross-feed screw, hence to advance the tool the required amount the cross-feed screw must be turned 2½ eighths of a turn, or a little less than 5-16 of a revolution.

When the thread to be cut on the pipe is No. 8, as it is on large sizes of pipes, the work must make about 10 revolutions while the tool is traveling from one end of the thread to the other. To cut a taper pipe thread with great exactness divide the circumference of the cross-feed hand wheel into 32 equal spaces. If there is no wheel, only a lever with crank and balance

ball, get out a disc of brass, tin or some other sheet metal and make it to slip over the nut which holds the handle on the cross-feed screw. Divide the circumference of the disc into 32 equal spaces, then when cutting the thread it is necessary to advance the cross-feed screw one of the spaces at each revolution of the pipe which is being cut with No. 8 thread. If other threads are to be cut a differently divided circle must be used on the cross-feed screw.

For instance, should it be necessary to cut a No. 11½ thread, the cross-feed disc must be divided into that number of spaces which will permit the disc to be turned the same fraction of a revolution—2½ inches—while the pipe is being revolved about 14 4-10 times—it requires that number of threads of 11½ pitch to make 1¼ inches of thread. Therefore the disc should be divided into 56 (and a fraction) equal spaces and one of these spaces turned ahead on the cross-feed screw at each turn of the pipe. But as it is not always convenient to make two discs the 32 spaced one may be used, one-half a space being advanced at each revolution of the pipe. The difference is so slight that the error will never be noticed in the completed thread.

TAPER-THREAD DIAL.

After the workman has cut pipe threads for some time he will be able to do without the graduated disc and run the cross-feed screw in by guess, and he can come very near to making a perfect thread, too. Still, the graduated disc on the cross-feed screw should be used by beginners, and by skilled mechanics when very accurate threads are required. The same method may be employed when it is necessary to cut bolt threads on a taper cylinder, or to turn tapers, as well.

The manner in which the dial is made and operated may be perhaps better understood by reference to Fig. 91. The cross-feed handle, A A, has fitted to its nut the brass plate B, and this plate in turn carries the dovetail circular clip C, which holds the pointer D. The circular edge of plate B is graduated, being divided into 32 equal portions as shown. By means of the pointer D any desired graduation may be indicated, as in the illustration; the pointer is shown at space 1.

It is very easy when the tool is cutting to turn the cross-feed handle one division on the brass plate at each revolution of the

pipe, and this will give the exact taper necessary to a perfect thread. While the tool is chasing along the length of the thread, being advanced one space each revolution, the lathe man has time to get ready for the next succeeding cut. It is always

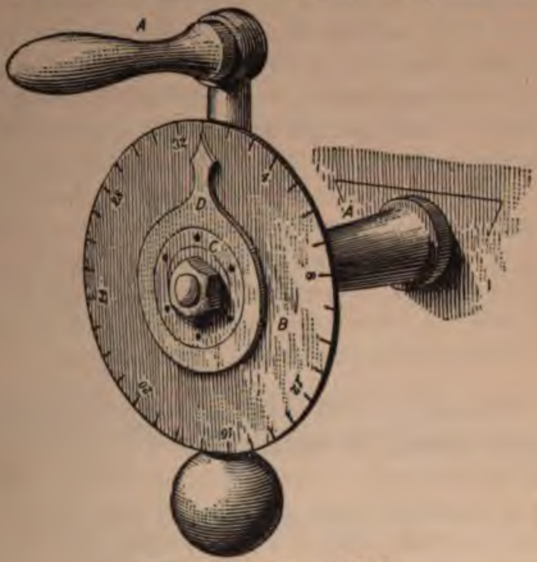


Fig. 91—Taper Thread Dial.

necessary to draw back the thread tool while running back the lathe carriage for another cut. The tool must be thus run back to prevent the lost motion in the lathe connections from letting the tool lag behind just enough to tear the thread during the return of the cutting tool by a reverse movement of the lathe.

During the progress of the cut the lathe man should move the index D enough to bring it to the left just the depth of the cut taken each time. Thus, if it be found that the depth of cut taken each time the tool travels along the pipe is equal to four spaces movement of the dial and hand wheel then during the progress of the cut, in addition to revolving the cross-feed screw one space each revolution, the pointer must be moved to the left four spaces and at the beginning of the next cut it must be brought uppermost when the screw is advanced again after the slide-rest has been run to the beginning of the thread.

That is, the lathe man runs the tool toward the work at the starting end of the thread and stops at the beginning of each

cut with the pointer uppermost. Then he sets the pointer four or more spaces to the left, for the register of the next cut, and starts the lathe, advancing the cross-feed screw one space at each revolution of the pipe until the end of the screw is reached, when he reverses the lathe, gives the cross-feed screw two quick revolutions backward to bring the tool clear of the thread, then reverses the motion of the cross-feed screw again when the lathe carriage reaches the commencement of the thread and has been put back to the forward or cutting motion again. The expert workman soon gets so that he can make the several movements without stopping the lathe, except for the two reverse motions necessary, and at the beginning of each cut the dial on the cross-feed screw is brought to a vertical position at the instant the tool reaches the beginning of the cut. A very fine and accurate job of taper turning can be done in exactly the same manner, but by using a suitable tool instead of the thread tool above mentioned.

THREADING PIPES LONGER THAN THE LATHE.

The arrangement for cutting off and threading a short pipe which can be held between centers or in chuck and steady-rest will not answer when a pipe much longer than the lathe must be cut off and threaded. This is a job to make the machinist smith open his eyes when it is asked of him, but the problem is not a hard one. It only requires a little rigging up to be successfully accomplished.

Say that a length of six-inch pipe was dumped in front of a ten-foot lathe with the request that twelve feet of that pipe be cut off the length and threaded. To do this remove the tail-stock from the lathe and set up the steady-rest about two feet from the face-plate, but put the slide-rest between the face-plate and the steady-rest. Put one end of the pipe in the rest, letting the point to be cut off overhang the rest toward the face-plate about three or four inches. If only a short piece has to be cut off it may be well to make two jobs of the work, catching the pipe in a chuck, cutting off as described in a previous paragraph, and afterward chucking the pipe as hereinafter described, with the end to be threaded overhanging the steady-rest three or four inches on the side next to the face-plate.

Next rig a bearing for the extreme end of the pipe. A scantling set on end between floor and ceiling, with a bit of iron

clamped on by means of a handscrew, is all that will be required. Failing the handscrew, nail a couple of bits of hardwood to the scantling, oil the place where the pipe revolves and go ahead with the pipe cutting. Another way to hold a pipe in this manner is to set up the scantling close beyond the end of the pipe. Bore a hole in the scantling, press the shank of the pipe center into the hole, slip the pipe over and against the pipe center, and the outboard bearing is all rigged, and it only remains to rig up some way to drive the pipe, the other end of which is a foot or two from the face-plate and fast in the steady-rest.

INTERNAL PIPE DRIVE.

Fig. 92 gives an idea of one of the many ways in which internal driving of the pipe may be accomplished. The pipe is

Fig. 92—Threading Long Pipes in a Short Lathe.

shown at A, the scantling with pipe center inserted appears at B, while the jaws of the steady-rest appear at C C, the body of the steady-rest and the slide-rest having been omitted from the drawing for the sake of clearness. Two pieces of flat bar iron, D D, are inserted in the end of the pipe as shown by the engraving and a block or a bit of iron—a nut, for instance—is slipped between the bars at E to act as a fulcrum in such a manner that when the ends of the bars next to the face-plate are pressed together the ends inside the pipe are pressed outward against the inside of the pipe, thereby obtaining such a grip against the pipe when the bars are rotated by the face-plate the pipe is carried with the bars, thereby effecting the driving of the pipe for purpose of thread cutting.

The next problem is to attach the ends of the lever bars to the lathe spindle in such a manner that they may revolve the pipe when the spindle is driven by belt. To this end the round iron F is bent to pass through the arms of a small face-plate, the rod being secured to the arms of the face-plate by means of nuts

and washers on the inside and outside of both the arms through which the rods pass. To secure a properly rigid connection between the iron bars and the round iron F a bolt is placed through both bars as shown at H, inside the round U-bolt F, thereby clamping the bars rigidly to the face-plate, also to the pipe A, which must therefore always revolve in unison with the face-plate. The pipe is also held rigidly endwise by the same force which holds the pipe firmly to the face-plate, hence there is no danger that the pipe can slip sidewise, as when on centers and held by a dog, neither can it slide endwise, no matter how flimsy may be the support of the tail-center B.

In order to make as rigid a connection as possible with the face-plate the bars D D should be as short and as stout as possible. There is no reason why the steady-rest should not be placed as close to the face-plate as possible and leave room for the slide-rest to traverse the distance required for the length of thread on the pipe. It is evident that when the bars D D are quite long there will be more or less spring to them, thereby allowing the pipe to rotate considerably under the pressure of the thread tool, but if the bars be made very short and as wide and thick as can be gotten into the end of the pipe, then there is little danger that the bars will spring enough to cause any trouble in the thread cutting.

When actually cutting the thread on a piece of pipe do not try to cut with a pointed tool. Cut the thread to nearly the finished size with at least 1-32 inch ground off the point of the tool. A thread tool thus squared off on the end will stand sharp much longer than if the attempt be made to cut the thread with a fine sharp point on the tool. After the thread is cut down almost to size then grind the tool to the correct shape for a finishing cut and run it lightly over the thread two or three times to clean out the bottom of the thread and a very nice cut will be the result.

THE END.

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